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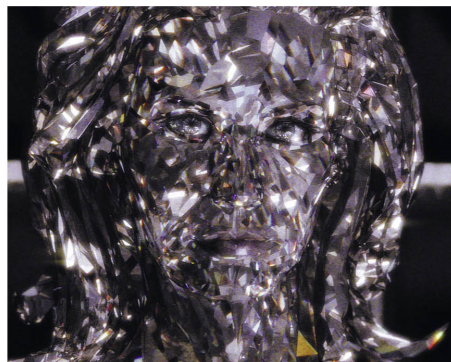
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God of Thunder

image

article by
Joe Fordham

In August 1962, the comic book *Journey Into Mystery* #83 introduced ‘The Mighty Thor’—a Norse god, banished from a mythic realm, who defended planet Earth against monstrous rock monsters from Saturn. *Thor*, created by Stan Lee in collaboration with Jerry Lieber and Jack Kirby, went on to become the star of myriad Marvel Comics adventures. But despite the recent deluge of comic book adaptations filling movie theaters, Thor’s cinematic debut was a long time coming. “One of the challenges in adapting *Thor* was the comic’s many different tones,” observed visual effects supervisor Wesley Sewell, who joined Marvel and Paramount Pictures’ *Thor* after assisting postproduction of *Iron Man*. “They had to figure out what to do with Thor’s human alter ego, Don Blake. In the original comic, Blake was a crippled doctor who found a cane in a cave; and he turned into *Thor* when the cane became a hammer, making him this mighty hero. That begged the question: was Don Blake a Norse God? Or was a Norse God piping through him, sharing a consciousness? It was complicated.”



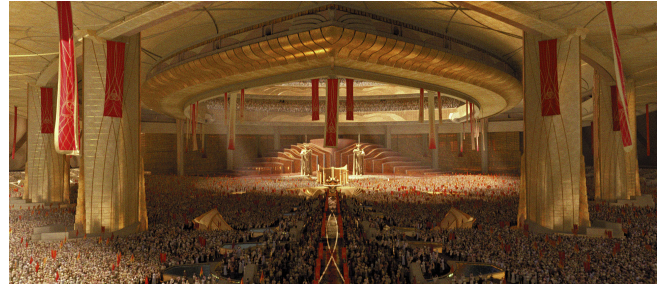
After years in development, Marvel Entertainment and Paramount Pictures released *Thor* as the first feature film based on the Marvel Comics’ character, a Norse god transplanted from his mythic origins in Asgard – a gleaming metropolis set among the stars – to become a superhero on planet Earth. Director Kenneth Branagh oversaw the adaptation as an action-packed tale that depicted the young god’s first terrestrial adventure. Visual effects supervisor Wesley Sewell guided the creation of fantastic realms with seven vendors, including Whiskytree, Buf Compagnie and Digital Domain, while Luma Pictures focused on earthbound effects.

Marvel Entertainment president and *Thor* producer Kevin Feige, together with executive vice president of visual effects and postproduction and co-producer Victoria Alonso, invited Sewell to discuss an early adaptation by Mark Protosevich that tied Thor's origins with Norse legend. "The script took place in ancient Scandinavia," observed Sewell. "It involved Thor's home of Asgard, as well as Svartalfheim, a realm populated with gnomes and dark elves that made the gods' weapons. It was a great dramatic epic, but Marvel had a big success with *Iron Man*, and they wanted to capture some of that tonality. That was difficult because *Iron Man*'s star, Robert Downey Jr., had brought his own persona to the title character and made it funny, contemporary and challenging. This other script didn't have that, so they decided to re-think it."

The screenplay evolved with screenwriters Ashley Edward Miller, Zack Stentz and Don Payne, and a story accredited to Protosevich and J. Michael Straczynski — writer of an acclaimed *Thor* graphic novel series. The narrative aimed to balance comic book adventure set in present day with a mythic origin tale. On the eve of his coronation, *Thor* (Chris Hemsworth) and his devious brother Loki (Tom Hiddleston) anger an ancient enemy, Laufey (Colm Feore), in the frozen realm of Jotunheim. Thor's father, Odin (Anthony Hopkins), king of Asgard, rages at his headstrong son for inciting war and uses an astral portal to dump the young Asgardian in the New Mexico desert. Stripped of his powers, *Thor* encounters astrophysicist Jane Foster (Natalie Portman) who teaches him humility, while back on Asgard Loki plots to make Thor's exile permanent.

With the screenplay taking more defined shape, Marvel took an equally circuitous route to find a director, finally arriving at Kenneth Branagh, best known for his film adaptations of Shakespearean plays. "When they first suggested Kenneth, it made sense," commented Sewell. "Thor was about a king, his princes, and the betrayal of Thor's brother, Loki. It was 'Shakespeare in Space!' I knew, too, that Kenneth was not scared to go for big cinema — the man shot *Hamlet* in 70mm — and when we met, he brought with him stacks of images for costume ideas, classical art references and Hubble space telescope photography. He was clearly a very visual artist."

Branagh's previous film — an adaptation of Mozart's *The Magic Flute* set in *World War I* — had introduced him to immersive digital environments, which the director was keen to explore for Thor's mythic realms. "Ken didn't want to play the film as fantasy," noted Sewell. "He wanted to play it as science fiction. That is where it clicked for me. The comic art was interesting and exciting, but some of it was fantasyland. For instance, in the comic, the Rainbow Bridge — which brings the gods to Earth — was a big swirly shape with stripes. Treating it as science fiction, we developed the idea that the Rainbow Bridge was inspired by ancient Norsemen seeing the aurora borealis. By that reasoning, *Thor* was an extraterrestrial, who came from an advanced civilization that had the ability



At the center of Asgard, King Odin (Anthony Hopkins) prepares to crown his eldest son, Thor (Chris Hemsworth), before the populace gathered inside the gargantuan royal throne room. Production designer Bo Welch built a soundstage set representing the central portion of Odin's throne room, which consisted of an enormous golden throne on a dais at the center of an elliptical chamber, surrounded by banners and backed by greenscreen. In postproduction, Whiskytree added environment extensions that expanded the throne room to several football fields across and added digital crowd assets with hand-animated motion cycles.

to traverse the universe.” Gods inhabited planets, known as Nine Realms, and used a ‘Bifrost’ wormhole network for rapid interplanetary travel to destinations including Midgard, a backwater otherwise known as Earth. “Earth is like a nature reserve, but Laufey’s Frost Giants love to visit because we have water they can freeze. Odin meanwhile protects us from evil, until his son Thor comes of age. It was a lovely take on the comic.”

Pinnacle of the Nine Realms was Asgard, a golden city built on remnants of a planet. Production designer Bo Welch designed Asgard sets that filled soundstages at Raleigh Studios in Manhattan Beach, California. A key visual motif for Asgard sprang from comic book art. “A lot of Jack Kirby’s designs had the look of fractal geometry,” said Sewell, “a simple mathematical code that when repeated yields beautiful organic patterns, like the structure of DNA. Our concept was that Asgardians had mastery of fractal technology and developed a mathematically based, but natural environment.” Asgard’s central structure, Odin’s tower, displayed the fractal theme in the layout of its soaring cylindrical structures, grouped in three intersecting ellipses. The three-petal motif also featured in set dressing, costumes and an engraving on Thor’s signature prop, the war-hammer, Mjolnir.

Blueprints and digital models of sets served as the basis for 3D animatics that previsualization supervisor Gerardo Ramirez developed with his team at The Third Floor. Previz data became the foundation upon which Whiskytree, one of the film’s four main vendors, built visual effects. “Using the production’s 3D models enabled us to continue the design phase well into postproduction,” commented Jonathan Harb, visual effects supervisor at Whiskytree. “A good example of that was Odin’s Tower. The art department built the first models, and we started with that geometry, but the design work continued for another eight or nine months.”

Early Asgard concepts included immense free-floating architecture crowned by coliseum-like arenas, and Whiskytree retained a vestige of the floating tower design in its city layout. “One building was made up of nine cylindrical slices that slowly rotated around one another,” Harb explained. “It was a piece of kinetic sculpture that represented the Nine Realms, and it demonstrated that Asgard was Odin’s construction, and Odin’s powers were without limit. If a building needed to float, it floated!”

Asgard’s main chamber, a vast gull-winged throne at the center of a gilded hall, filled the largest soundstage at Raleigh Studios and then grew in stature during postproduction. “Bo and his team built a petal-shaped room with massive golden pillars and a big area in the back where the throne sat,” related Wesley Sewell. “Outside that, we hung big golden banners; and beyond was greenscreen, where we planned to add a view looking out over Asgard. As it turned out, we relocated the throne room lower in Odin’s tower, and the banners



After unwanted visitors from a rival realm interrupt the coronation, Thor and his companions ride out across the crystalline Rainbow Bridge that leads from the heart of Asgard to a gilded spherical observatory, gateway to an interstellar transportation device known as the Bifrost. The production built a section of the bridge as a practical set, internally illuminated by pulsating lights. BUF created set extensions, using Whiskytree elements of the distant city, and added the observatory, multi-colored light effects flowing through the bridge, and a vast ocean that encircles the city and falls away like a waterfall into a cosmic abyss.

obscured our view. When Whiskytree added extensions, we digitally removed the banners and the scale of everything got huge. For Thor's coronation, all the population of Asgard gathered into this vast area, and we placed our set in the middle of that."

Sewell and visual effects producer Diana Giorgiutti assigned Asgard's outskirts to Buf Compagnie, which generated key scenes involving characters leaving and arriving via the Bifrost. Digital Domain joined the team to furnish effects for the Frost Giant realm of Jotunheim and a prologue involving Frost Giants on Midgard. Luma Pictures handled all earthbound effects — most in the film's second act — while Fuel VFX and Evil Eye Pictures handled additional effects.

Upping the ante for all vendors was an initiative to convert images into stereoscopic 3D during postproduction. "Our production schedule would have expanded 25 percent if we had shot the movie in native 3D," observed Sewell. "I felt that new technologies made stereo post-conversion feasible." Using sample footage from *Iron Man*, Victoria Alonso commissioned tests at several 3D post-conversion studios, and then awarded work to Stereo D in Burbank, California. Conversions fell into four categories. "Fifty percent were Type One straight conversions — dialogue scenes and simple visual effects — which we handled at Stereo D. Type Two conversions involved all-CGI shots, and our vendors handled those. Type Three shots involved atmospheric effects, like mist or snow. We generated a limited amount of those effects practically on set, and then augmented them in 3D. Type Fours involved volumetric effects that would have been impossible to post-convert. In those shots, Stereo D generated right- and left-eye conversions of plates, and then our vendors used those to generate effects in 3D."

On the physical effects front, special effects supervisor Daniel Sudick provided floor effects, mechanical rigs and pyrotechnics. For special wardrobe needs and armor, costume designer Alexandra Byrne worked with specialty costume manufacturers Film Illusions and Ironhead Studio, both of which handcrafted armor using body forms generated from cyberscans of performers. "Comic book character costumes are all about the flow and form of the design," said Russ Shinkle, owner of Film Illusions, "and that's why it was critical to have precise body scans. Chris Hemsworth had a powerful build and very specific body type, and we sculpted onto his body form the old-fashioned way, in clay, which allowed us to make modifications on the fly." Film Illusions key sculptor Scott Ramirez sculpted Thor's armor, which included a layered breastplate and intricate arm coverings. Mold shop supervisor Dan Crawley generated molds, output soft pieces in foam latex and manufactured rigid forms in urethane, which were then electro-plated with metallic finishes. Film Illusions also generated Odin's armor as hand-sculpted fiberglass pieces electroplated in 24-karat gold, created armor for 30



Heimdall (Idris Elba), a fearsome sentry clad in gold, stands guard outside the entry to the Bifrost observatory. Costume designer Alexandra Byrne used specialty costume designers to manufacture custom armor pieces for Asgardian characters. Among them was Film Illusions, which generated the majority of Heimdall's armor parts in fiberglass, with mechanical articulation around the shoulders, and urethane rubber parts around the waist. Artists electroplated pieces in gold and then applied hand-painted aging effects. Branagh filmed the character in a partial set backed by greenscreen. BUF generated environment extensions and cosmic backgrounds.

members of Odin's Einherjar guards, and crafted elaborate battle armor for the Bifrost sentry Heimdall.

Ironhead Studio created Thor's winged helmet, working from Marvel designs. "We worked with Alexandra to distill Marvel's designs into a sculpt that had the main section of the helmet coming down onto Chris' face," stated José Fernandez, owner of Ironhead Studio, "and then we applied wings in a secondary layer." Ironhead lead artist Eric Harris oversaw manufacture of the urethane pieces, which were clad in two-tone mirror chrome. Ironhead also created a 12-piece ceremonial armor and a battle helmet for Loki that featured elaborate horns made of lightweight fiberglass, and battle armor for members of Thor's warrior clan.

Also realized practically were the Frost Giant inhabitants of Jotunheim. "Very early on," commented Wesley Sewell, "Kenneth Branagh and Kevin Feige asked if we should do the Frost Giants CGI — although Ken made it clear that he preferred to work with actors on set, rather than on a motion capture stage. We decided, because Frost Giants had closeups and long dialogue scenes, we would get the best results with practical creature effects, and we turned to Legacy Effects. Marvel had a great experience working with Legacy on *Iron Man*, and they were keen to work with them again."

Legacy Effects supervisors Shane Mahan and Lindsay Macgowan led the creation of the Frost Giant makeups, starting with digital renderings by in-house conceptual designers Scott Patton, Ian Joyner and Simon Webber that were used as the basis for the characters, with additional input from production illustrator Michael Kutsche and other members of Marvel's design team. Legacy artist Jason Matthews then created a full-size Frost Giant bust. Together, the artists arrived at a depiction of a brutish tribe of blue-green warriors with vivid red eyes, savage pointed teeth, scarifications and translucent green jade armor.

Legacy created a test makeup for six-foot-three creature performer Richard Cetrone. Prosthetic artist Christopher Swift sculpted facial prosthetics, while Scott Stoddard, Mike Manzel, Richard Alonso and Paul Mejias sculpted the full body suit. "They shot tests of in-camera forced perspective effects," stated Shane Mahan. "The makeup looked beautiful, and in dailies it looked like there was a nine-foot-tall giant talking to Thor."

Legacy sculpted nine hero Frost Giant makeups from head to toe in clay, each with a distinctive look, including King Laufey's demonic character sculpted by Arjen Tuiten. To create Frost Giant body suits, Legacy first fitted spandex under-suits to creature performer body forms, providing a foundation for foam latex skins. Mold shop supervisor Damian Fisher and foam and silicone lead Cory Czekaj then oversaw injection of liquid foam into body molds. Fused to the spandex, the upper portion of the suit slipped over the performer's head like a sweater, and cinched against the body by way of laces around the waist, sternum and crotch. "The suit fit tight to the performers' physiques,"



Heimdall inserts his sword into a mechanism at the center of the observatory, unleashing arcs of plasma that dance around the dome and open up a spinning Bifrost portal to transport Thor and his companions to another realm. Bo Welch's team designed the observatory set using 3D modeling techniques, from which they milled practical set pieces. BUF referenced the data to build a 3D model that completed the dome, and also added energy arcs, the Bifrost portal and a swirling mechanism beneath the observatory floor.

noted Lindsay Macgowan. “The sculpted muscles felt very organic when they moved; and because we didn’t have a seam, we didn’t have to hide a zipper. Shane and I are often frustrated by the limitations of a suit with a visible seam; that’s why we separated the body at the waist, so anyone who might be looking for the seam would wonder, ‘Where did they hide that?’”

Eight weeks prior to shooting, the production requested nine additional Frost Giant suits to fit larger stunt performers. “Chris Hemsworth is a tall actor,” said Shane Mahan. “They discovered that when he was eye-to-eye with Frost Giants, they couldn’t make the scale-gag work with actors his size — they needed actors at least seven feet tall.”

Legacy recruited 25 makeup artists to apply Frost Giant makeups, coordinating with makeup artists Ve Neill and Arjen Tuiten and utilizing the talents of Greg Cannom, Mike Smithson, Kevin Haney, Scott Stoddard and Richard Alonso, among others. After fitting upper bodies, artists glued suits around the neck and then began the three-hour process of applying eight or nine silicone facial prosthetics to each character. Frost Giant performers then slipped into legs, with separate feet and hands to allow for wear and tear. Scleral contact lenses and dental prosthetics completed the effect, with a mouthwash of blue food coloring adding pigmentation inside the performers’ mouths. Semi-translucent urethane armor adornments then snapped around the characters’ wrists and waists to conceal seams. Artists used Alcone ClearIce to create frosty ice effects and to perform speedy repairs if latex skins were damaged during rigorous stunt action.

The film begins on Earth, with Jane Foster viewing strange lights in the New Mexico night sky. Luma Pictures digital effects supervisor Justin Johnson accompanied the shoot to gather survey data in Santa Fe. Luma then generated blue-green phosphorescent aerial phenomena. “We animated combinations of volumetrics, cloth-simulated ribbons and particle effects,” stated Luma CG supervisor Richard Sutherland. “The effects were based on aurora borealis, but translucent and compact, centered around a wormhole in the sky.”

The aurora gives way to a descending, illuminated conical disturbance in the clouds, which then whips up a dust storm. Daniel Sudick’s special effects team provided wind machine effects for actor interactions, and then Luma generated a vortex that engulfs the characters. “We went through many different styles of Bifrost effects to find something that didn’t feel overly fantastical,” said Luma visual effects supervisor Vince Cirelli. “We didn’t want it to emit too much light, but it needed to appear to support the Rainbow Bridge. We ended up with a very gritty super-tornado that contained streams of energy.” Luma developed an animation rig to control the speed and rotation of the Bifrost, then ran multiple volumetric particle simulations to create swirling dust. “One of the challenges was figuring out how to render very dense voxel simulations. We came up with a way of



Thor leads his fellow Asgardians to the frozen world of Jotunheim, seeking out an ancient rival of Odin’s whose realm has long ago fallen into decline. The production filmed performers arriving on Jotunheim on a minimal set backed by greenscreen. Digital Domain generated environment extensions based on nature studies of arctic terrain, and built large models to represent Jotun architecture constructed from dark jagged rock clad with smooth outer surfaces. Effects artists used dynamic simulations to create chunks of falling rock, and layered scenes with volumetric drifting snow to create a majestic sense of scale.

partitioning simulations, generating sections of the Bifrost at very high resolutions. We then exported those into Autodesk Maya and rendered them in correct stereoscopic space.”

Rotoscope and digital paint supervisor Glenn Morris and his team blended dust effects around performers, creating realistic Stereo Depth separations. To reveal *Thor* sliding down the Rainbow Bridge and landing on the desert floor, Luma artists generated a digital double from scans and texture reference of the actor, which they animated and matchmoved to Hemsworth.

The story backtracks to explain Thor’s origins in a flashback set during the *Dark Ages* in Tønsberg, Norway, where Laufey and his Frost Giants attack a Viking village. Production constructed a small village set on a Raleigh Studios soundstage, surrounded by greenscreen supplied by The Rag Place motion picture technical fabric supplier. Digital Domain extended the environment. “We found some very nice topography of mountain landscapes that resembled Nordic fjords,” explained Digital Domain visual effects supervisor Kelly Port. “We used that with a combination of texture maps and digital projections, and created a 360 environment around the village.”

Laufey attacks via a luminous Bifrost vortex that extends toward a lake. Digital Domain CG supervisor Karl Denham and compositing supervisor Joel Behrens, working out of the company’s Venice, California headquarters, generated Bifrost effects by blending volumetric particles and lighting effects, and then created icy blasts from a Jotun weapon — the ‘Casket of Ancient Winters’ — which Laufey discharges, causing the lake to freeze. “It freezes the lake surface,” said Port, “blows up pieces of ice, and the underlying water freezes again. We simulated all of that.”

Frost Giants wield weapons made of ice to hurl freezing liquid over villagers, encasing them in ice. Legacy created urethane and vacuform weapons for stunt performers to wield, and then Digital Domain generated effects of ice freezing in midair. “We animated fluid simulations of ice waves,” related Port. “On top of that, we added horizontal ice spikes. We did a lot of custom modeling to control the formation of those shapes. Then we blended fluid simulations around them, and rendered refractions to make the ice read in the moonlight.”

Odin and his Einherjar guards arrive via another Bifrost emission and engage Frost Giants in combat. To juxtapose Asgardians and Vikings with towering Jotun warriors, Digital Domain enhanced forced perspective scale tricks with digital composites, painting out and rescaling characters. Where 2D solutions were not possible, modelers generated digital double Frost Giants, most of them in the background to increase the scope of the battle. To generate fight action for animated crowds, Digital Domain used data from Giant Studios motion capture sessions, which



For the ten-foot-tall Frost Giants of Jotunheim, Kenneth Branagh favored a practical approach, using makeup effects created at Legacy Effects, which allowed the filmmakers to capture long dialogue scenes between Asgardians and the villainous Jotun king, Laufey (Colm Feore), in camera. The production then use forced perspectives to create illusions of scale. Digital Domain augmented the in-camera effect with digital composites, inserting Frost Giant digital doubles where needed. Legacy Effects sculptor Arjen Tuiten adds details to Colm Feore’s Frost Giant sculpture.

they applied to the Frost Giant and Asgardian warrior digital doubles. Animation supervisor Eric Petey provided cycles of keyframe actions where needed. Technical directors used RIB archive crowd replication to generate crowds from action clips and keyframe cycles, intermingling live and animated characters.

The flashback ends with a transition to Asgard where Odin recounts his cautionary battle story to his two young sons, Loki (Paul T. Moore) and Thor (Dakota Goyo). To introduce Odin's home world, the production generated an epic journey through the cosmos. "We travel through space toward what looks like a galaxy's edge," related Wesley Sewell. "As we get closer, we realize it's made of clouds, not stars. The camera approaches a mountain covered in rainbow crystals with an ocean around it. We fly down into the water to the underside of Asgard and then come out to see the golden, gleaming city."

BUF generated the Asgard approach. "Marvel challenged us to deliver a superhuman spectacular universe never before seen," recalled BUF founder Pierre Buffin. "Many of the elements were familiar from mythology and the comic book, but it was another matter to represent them in a realistic manner, and to show how they were constructed."

BUF visual effects supervisor Nicolas Chevallier, visual effects producer Pierre Escande and more than 100 artists at the company's studio in Paris spent a year developing effects, taking inspiration from imagery of nebulae, Mandelbrot fractal imagery and comic book art. "We made reference to Jack Kirby's drawings of nebulae that looked like 'scars' in the sky," said Nicolas Chevallier. "We blended those very recognizable shapes with more realistic Hubble telescope imagery and images from Celtic mythology. We used a lot of particles, volumetric shaders, high-detail textures and recursive modeling in the final shots."



Frost Giants were envisioned as brutish warriors with a blue-green pigmentation, covered in scarifications and adorned with translucent green jade armor. Legacy sculptors Bruce Fuller, J.D. Bowers and Clint Zoccoli tend to one of nine custom full-body makeups generated for foreground Frost Giant performers.

Whiskytree segued from BUF's shot, with the camera ascending from the ocean to swoop down over the city. Whiskytree used procedural modeling to generate terrain details, combined with hand modeling and scenic projections. "The production wanted to see a lot of cliffs relatively close up," observed Jonathan Harb. "That kind of detail required photographic reference; and so, we used images of Black Canyon in Colorado's Gunnison National Park, which has dramatic rock walls. We did procedural modeling as much as possible, and then projected textures on top." Whiskytree matte painting supervisors Susumu Yukuhiro and Joshua Ong and their teams experimented with varying degrees of detail for Asgard's architecture, but the production ultimately employed a golden-toned theme throughout. Whiskytree also expanded live-crowds. "We built crowd assets in Softimage, hand-animated them, created cycles and then placed them around Odin's throne room, which we extended to the size of several football fields."

CG supervisor Votch Levi oversaw Whiskytree's tools development, technical processes and rendering. 2D supervisor Brandon McNaughton led Whiskytree's compositing crew, and art director Joe Ceballos solved many concept and design challenges unique to Asgard. "The original plan was for all Asgard scenes to take place at twilight," observed Harb. "We still see a lot of twilight, but for editorial reasons, we ended up seeing Asgard at nighttime and daytime, too. That was tricky because the golden city looked great in daylight, but when we lit the same materials for night, they looked like a chocolate bar."

The Asgardian idyll ends when Frost Giants interrupt Thor's coronation, breaking into Odin's vault in an attempt to retrieve the captured Casket of Ancient Winters. Production filmed the scene with three Jotun performers in Legacy makeups. Digital Domain and Luma Pictures augmented the scene with digital doubles and set extensions. "The scene changed during editing, and we ended up replacing most of the Frost Giants in Odin's vault with digital versions," said Wesley Sewell. "We used a practical creature hand as one Giant makes contact with a wall, turning it to ice. We also had a shot over the Casket where three practical Giants run up to it, and dead Frost Giants were all practical."

Enraged at the incursion, *Thor* leads a covert retaliatory mission into Jotunheim, riding out with his companions across a crystal bridge that leads to the Bifrost embarkation point. "In all descriptions in comic books and Norse mythology," related Sewell, "there is a bridge that characters walk out to, and a gatekeeper, Heimdall, who must grant permission to use the Bifrost. We created a science



King Laufey greets Thor in the remnants of his crumbling palace. Feore wore a seamless foam latex upper body piece, which makeup artists glued around the neck and blended into silicone facial appliances. Urethane armor pieces around the waist and wrists hid the blend to hands, legs and feet.

fiction version of that with a Bifrost machine inside what we called ‘Heimdall’s observatory.’ Bo Welch designed a domed set, built out of 3D modeled, computer-milled sections — another example of fractal replication. BUF built a CG version and painted in the rest of the dome. Beyond the doors, we had greenscreen and a section of the Rainbow Bridge.”

The 60-foot-long, 30-foot-wide bridge section was inlaid with one-inch plexiglas, supported on five-foot stanchions. Director of photography Haris Zambaloukos created in-camera effects of energy flowing through the bridge, using lights on chasers beneath the plexiglas. BUF added rainbow colors to the bridge in postproduction. To create reflections of performers in the crystalline structure, set dressers applied mylar film to the surface of the set. To mask unwanted reflections of rigging above the stage, the grip department designed a mechanized greenscreen on a crane. “We could swing the greenscreen into view and tilt it on motors,” said Sewell. “Each time we did a take, we repositioned the rig to reflect green behind the actors. When we stripped away the greenscreens in our composites, the crystalline rainbow effects sat in there beautifully.”



After Odin banishes Thor to exile on Earth, Thor’s brother Loki (Tom Hiddleston) – rival to the Asgardian throne – uses Jotun magic to encase the giant sentry Heimdall in ice and thus gain access to the Bifrost. Branagh filmed the scene with Idris Elba reacting to the blast of icy energy that melds him to the Rainbow Bridge. BUF generated a 3D model of the character from scans of the actor and created the icy blast encasing his body by simulating fluid particles, then translating them from fluid to crystalline properties.

Nicolas Chevallier and BUF producer Audrey Tondre accompanied the Rainbow Bridge shoot, gathering witness camera data and approximately 8,000 images of the set. BUF then generated the observatory, stanchions, ocean, a backdrop of stars and the Rainbow Bridge. Whiskytree provided elements of distant Asgard, which BUF translated into its proprietary render system. “BUF sometimes asked us to isolate very specific passes of the Asgard background,” stated Jonathan Harb. “They requested an albedo pass, which we would approximate with renders of several shader components. That allowed them to create lit geometry that was missing its textures, but still had its color. They could then project other passes of the background onto matching geometry that we provided and re-create lighting effects without getting into umpteen billion textures on each and every building.”

For elements of *Thor* and company traversing the bridge on horseback, the filmmakers shot at Torrey Pines State Beach, north of San Diego, rather than shoot on the perilous bridge set. “At certain times of the day, the water came up this long shallow beach and created a reflective surface before it washed away,” said Wesley Sewell. “On our last day of shooting, we went down to the beach with stunt riders in costume. We positioned our camera so we could see their reflections with a bright blue sky behind them, and we had them ride along the beach just as the waves came in.” BUF rotoscoped riders and reflections and tracked them to the Rainbow Bridge with silhouetted figures shimmering against the structure’s rainbow energy. Whiskytree generated composites of Asgard and the golden gateway through which the characters ride.

Inside the observatory, the warriors meet the fearsome sentry, Heimdall (Idris Elba), who allows Thor and his companions to enter the Bifrost, activating a swirling energy portal. BUF generated the Bifrost entry as a violent kinetic transition. “The production wanted to be sure this was not a teleportation,” observed Pierre Buffin. “Our goal was to show that the characters were taken by the light with a very unpleasant effect on their bodies. We did that by building characters in 3D, filling them with particles and then stretching their bodies and animating them away in a light effect. It was more an acceleration than a dematerialization.”

For scenes of characters traveling along the Bifrost, hurtling through space, Wesley Sewell staged elements of performers suspended vertically against greenscreen. Hanging characters were positioned in triangular formation, Thor uppermost, while Daniel Sudick’s team buffeted them with air movers and the camera glided past on a remote controlled head. Fuel VFX generated cosmic backgrounds and Bifrost effects to suggest the stretching of matter that — theoretically — would happen at the speed of light. Theoretical science also suggested an apropos visual anomaly. “When you get close to light speed,” said Wesley Sewell, “the spectrum shifts and makes a rainbow. That fed into our concept of the Rainbow Bridge and our suggestion that the Bifrost was a form of interstellar travel.”

Fuel CG supervisor Roy Malhi and compositing supervisor Tim Walker produced Bifrost effects employing combinations of Maya, Houdini, Photoshop, After Effects and custom software scripts. Wide shots featured digital Asgardians. For closeups, Fuel generated a three- -dimensional environment around greenscreen elements. “We used stereo-extracted footage of the actors,” said Fuel visual effects supervisor Paul Butterworth. “We then mimicked camera perspectives to wrap effects around the characters. We painted out wires and added camera shake, as well as energy ribbons generated with stylized particle effects.”



For scenes of Heimdall frozen at the entrance to the observatory, Legacy Effects created a likeness of Idris Elba from lifecasts of the performer and photographic reference of the character’s costume. Legacy Effects co-supervisor Shane Mahan and special makeup effects artist Mike Manzel attend to the frozen dummy on set.



Shane Mahan and Legacy Effects co-supervisor Lindsay Macgowan use bonding agents and artificial snow spray to detail the Heimdall dummy before the application of translucent urethane pieces that fit over the form to simulate the outer shell of ice.

Thor and his companions land on Jotunheim beside a precipice and then head for Laufey's palace. Branagh filmed performers on a patch of icy ground surrounded by greenscreen. Digital Domain's Vancouver studio completed the sequence under the guidance of CG supervisor Eric Fernandes and compositing supervisor Mark Richardson, generating a chasm four times the size of the Grand Canyon with giant crumbling columns of rock and ice. "We created huge remnants of old architecture and giant towers hundreds of feet tall," stated Kelly Port. "They were huge CG models, conveying the idea that Jotun architecture was comprised of the natural minerals of that world. They used stone to create vertical shafts and columns, and then applied a smooth outer surface. Now degraded, the buildings' substructure is revealed, with pieces falling apart."

"The city was laid out like a fractal snowflake," elaborated Wesley Sewell. "It was made up of magnificent towers with sections stretching off radially in a very muted bluish palette. When the Asgardians arrive in their colorful costumes, they are definitely fish out of water." Laufey's palace, glimpsed in the prologue, is now revealed in disrepair. Production built lower portions of the palace surrounded by greenscreen, and then Digital Domain extended columns and modeled surrounding terrain.

Fighting breaks out, and Thor obliterates Jotuns and their architecture with blows of his war hammer, which spins and boomerangs back into his hand. On set, Chris Hemsworth worked with a lightweight stunt hammer or tennis balls on a rope to perform Thor's hammer-swing. "Quite often," said Sewell, "the simplest solution was to have Chris mime the hammer throw because we needed his swing to look so high-speed. To practice catches, propmaster Russell Bobbitt would throw a hammer from 20 paces, and Chris could catch it. The athleticism of that man was remarkable."

Digital Domain generated handoffs between the Mjolnir prop and a high-resolution CG hammer for shots of the airborne weapon grazing the camera lens in stereoscopic depth. For shots following Mjolnir's flight from Thor's hand and its collision with Frost Giants, Digital Domain generated 3D recreations of the Jotunheim environment and animated Frost Giants using motion capture data,



In an attempt to make Thor's exile permanent, Loki uses the Bifrost to send an emissary to Earth, directing the Bifrost beam to impact the New Mexico desert and causing consternation in the nearby town of Puente Antigua. The production filmed Puente Antigua scenes at Cerro Pelon Ranch in New Mexico, where the art department and construction teams modified a standing set of an Old West town with contemporary trappings. Luma Pictures added digital set extensions to expand the practical set, and generated stormy skies and a tornado-like cloud formation, built from volumetric particle effects, to simulate the Bifrost.



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keyframe animation and textures gleaned from plate photography.

During the fray, a Frost Giant grabs Volstagg (Ray Stevenson), causing his arm to necrotize with frostbite — a wound applied by the production’s makeup department. Digital Domain then tracked Stevenson’s arm, and generated sizzling flesh by texture-mapping an element of boiling Muenster cheese. When a Frost Giant makes contact with Loki, the contact has an unexpected effect, momentarily transforming his flesh into blue-green Jotun pigment. Digital Domain tracked Frost Giant skin texture to a CG duplicate of Hiddleston’s arm, then introduced three-dimensional scarifications. Digital Domain shattered a digital version of Loki’s glove that falls apart as if dipped into liquid nitrogen.

While Thor wards off Frost Giants, his companions flee to the Bifrost departure point, vaulting crumbling ice fields. Daniel Sudick’s team created practical shifting ice effects using a series of 16 gimbal-mounted platforms across which performers ran while technicians caused set pieces to tilt with hydraulic controls. Digital Domain tracked performers through shots and added crumbling ice, generated with dynamic simulations.

Thor joins the escape when Laufey causes a monstrous Frost Beast to erupt from the ice. Digital Domain designed the creature in tandem with Marvel, and then modeling and texture lead Miguel Ortega built a digital model in Maya, ZBrush and Mudbox, which modeler Christopher Nichols textured using reference of pachyderms and turtles.

“We used turtle reference for the Frost Beast face,” related Miguel Ortega, “re-creating crusted skin effects that occur around turtle beaks. The Frost Beast had somewhat limited facial articulation, because he had no lips, but the teeth were all exposed, like the Rancor beast from *Return of the Jedi* — that was a huge influence. A note from Marvel said that they wanted a rhino meets a lion meets the Rancor.”

Eric Petey’s team animated the Frost Beast to plummet through a subterranean ice cavern and cut off the Asgardians’ escape. Thor then dispatches the leviathan with an airborne hammer blow. “It was a fantastic shot,” commented Kelly Port. “The creature was backlit by the sun, which gave it a very graphic feel as Thor leapt through its mouth and tore the flesh out the back of its head like a bullet going through an apple.” Nichols and Ortega added a flap of skin and exploding gore, and then, as the Frost Beast fell, added a hole through the head with chunks of dangling meat generated as Mudbox displacements.

Luma Pictures added digital set extensions to expand the practical set and generated stormy skies and tornado-like cloud formation, built from volumetric particle effects, to simulate the Bifrost. Mechanical giant in conceptual renderings, which Legacy then scaled up to create a nine-foot-tall fiberglass prop that the production used on set as lighting and scale reference. Luma Pictures used 3D data of the creature design to generate Destroyer as a keyframe- animated character detailed with dynamic simulations of Asgardian alloys.



Seeking Thor and a group of his allies from Asgard, Destroyer strides into Puente Antigua and lets rip with its energy beam in wanton acts of destruction. Special effects supervisor Daniel Sudick and his team rigged the New Mexico set with extensive practical effects to simulate interactions of Destroyer’s energy beam tearing into buildings, overturning cars and, at one point, causing a gas station to explode. Luma Pictures layered in the animated figure of Destroyer and the energy beam, and augmented practical fire effects using digital simulations that gave the explosion a supernatural Asgardian feel.

Frost Giants close in around *Thor* and his companions, until the Bifrost opens and Odin appears riding an eight-legged steed, Sleipnir. For wide shots, production filmed a stunt double on horseback on a greenscreen stage. Digital Domain composited extra legs to the horse for closeups, and for wider shots generated a digital double of Odin astride a custom creature model. “The full-CG Sleipnir had a longer body and another row of legs tucked behind his forelegs,” explained Miguel Ortega. “The hind legs had one main thigh muscle and two bones came out from that, forming two legs on each side like a scissor arrangement. Chris Nichols built and textured that model. It was much more stylized than the real horse, but we were able to do that because the shots were strongly backlit.”

Odin leads the way back to Asgard and, furious with his son for breaking his tenuous treaty with Laufey, strips Thor of his armor and banishes him to Midgard. For shots of *Thor* hurtling to Earth, Wesley Sewell filmed greenscreen elements of Chris Hemsworth in a greenscreen wire rig. Fuel VFX then used a digital double for wide shots depicting violent propulsion. “We animated *Thor* tumbling crazily through the Bifrost and then applied fluid simulations,” related Paul Butterworth. “We wrapped him in a series of shockwave structures as if he was breaking through the light speed barrier.”

Thor lands on Earth without his superpowers and without Mjolnir, which Odin casts into the Bifrost to land deeper in the desert where agents of SHIELD — the government’s Strategic Hazard Intervention Espionage Logistics Directorate — erect a research camp around the immovable hammer. Luma animated Mjolnir’s fall in a wide shot of desert terrain using particle effects to emulate a distant meteor impact. For views of the impact site during the hammer’s discovery, Luma enhanced a practical crater with a 3D matte painting. For closeup interactions with Mjolnir, Luma experimented with magical effects of hammer glow and lightning, but ultimately kept interactions low key. “Mjolnir effects were very earthy and realistic,” observed Richard Sutherland. “We added some subtle enhancements, making Odin’s emblem appear on the hammer with a little 3D relief. Most of the time on Midgard it was inert, only activated by Asgardian magic when *Thor* is judged worthy.”

Back on Asgard, Loki again transforms into blue-green pigmentation and learns a disturbing fact that he is of Jotun heritage. Luma conceptual designer Loïc Zimmermann based the look for Loki’s transformation on reference of Legacy’s Frost Giant makeup. “We created a digital double face from a cyberscan of Tom Hiddleston,” said Vince Cirelli. “We added veining effects, and then matchmoved and layered that over the plate, so Loki turned from his Frost Giant face back to his Asgardian godly look.” Odin informs Loki he was a Jotun foundling whom he rescued during the raid on Midgard.

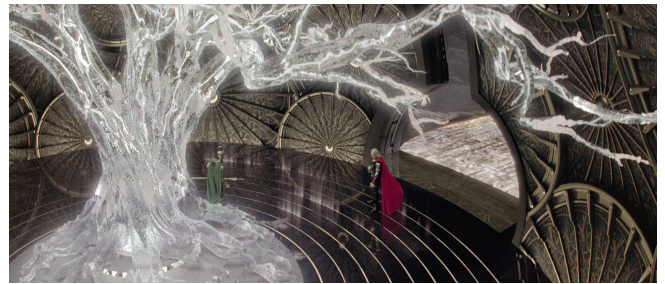


Stripped of his Asgardian powers, Thor ends Destroyer’s rampage by confronting the giant robot amid the wreckage of Puente Antigua’s main street and addressing Loki, who controls the robot by remote control from Asgard. The production filmed Hemsworth walking through burning wreckage in the street. Luma Pictures added Destroyer, together with digital set extensions and digital models of additional vehicles in proximity to Destroyer. Compositors blended practical elements of smoke and burning wreckage filmed on location into the plate.

Digital Domain created the effect of the Jotun child in Odin's hands for a flashback scene, mapping digital textures onto an infant.

The emotional confrontation with Loki takes its toll on Odin, and the aging king falls into a trance-like state of Odinsleep. Branagh filmed scenes of Anthony Hopkins in repose using an intense light source directed onto Odin's sleeping chamber. Fuel VFX added an energy effect to encase the performer in a luminous protective cocoon. "The effect was drawn as a light beam in concept frames," recalled Paul Butterworth. "But it needed to work for stereo, so we played with the idea that it was a volumetric energy surface, full of clouds and particles like auroras, sun coronas and little flame effects that ran across the surface." Fuel used fluid simulations to create surface features as volumetric effects. Artists rotoscoped bystanders at Odin's bedside, then tracked the top layer of a sphere over Odin's bed and applied effects together with a soft interactive glow that illuminated Loki and his mother Frigga (Rene Russo) with shifting caustic effects and a burnt umber glow.

Loki's ambitions to usurp Odin's throne provoke arguments with Thor's companions, who leave for Midgard, and then with Heimdall, whom Loki incapacitates using the Casket of Ancient Winters. Legacy Effects generated a frozen replica of Heimdall encased in ice from lifecasts of Idris Elba and photo reference of Film Illusions' armor. BUF reconstructed the frozen character in 3D and generated effects to represent the icy blast encasing his body. "We covered Heimdall with ice by simulating fluid particles," said Nicolas Chevallier. "The challenge was to transform a fluid simulation into a crystalline one, so we developed custom tools to refine the structural properties of the simulation." For later shots of Heimdall breaking free from the ice, BUF transitioned from the frozen prop to the performer in an explosion generated from the 3D model.



Thor returns to Asgard and faces off with Loki in Heimdall's observatory, where Bifrost energy has frozen into a giant crystal tree with icy tendrils extending across the domed ceiling. The production filmed the frozen energy effect using a translucent resin prop representing the trunk and portions of the roots of the crystal tree on set. BUF added digital set extensions of the observatory dome and exterior environment, extended the crystal tree's roots and branches and, in some shots, replaced the practical tree with a CG version, which digital artists re-lit to create more refractive effects.

Via the Bifrost, Loki sends to Midgard an emissary — a fearsome robotic giant, denizen of Odin's vault of ancient weaponry, known simply as 'Destroyer.' Marvel commissioned conceptual artists E.J. Krisor and Tully Summers to develop ZBrush concepts of Destroyer, which Legacy translated into a workable 12-inch-tall maquette. The maquette was digitally scaled up and milled to Destroyer's nine-foot height. Legacy refined the original sculpture, then generated a fiberglass prop, airbrushed with a tarnished gunmetal gray metallic finish. The prop was mounted on a wheeled base, and was designed to come apart at the waist, neck and arms, allowing filmmakers to position sections for lighting and scale compositions.

The stand-in served as reference for the New Mexico shoot of Destroyer's arrival in the desert, where it obliterates a squad of SHIELD agents' cars. Luma handled Destroyer animation, using 3D data from the ZBrush model to produce a proof-of-concept test in just two weeks. "We got that data into Maya," commented Luma visual effects producer Steve Griffith. "We rigged it and built shaders

from metal reference. We felt it would be more effective to light him in a real-world environment rather than a generic turntable because he was a giant reflective object, so we got permission to shoot reference of Odin's vault. From that, we created a rough 3D environment, projected on the textures, put Destroyer in that environment, animated a camera move around him and had him turn his head to camera to release a blast of fire. It looked pretty bad-ass."

Luma lead rigging technical director Thanapoom Siropopungul developed animation controls that articulated Destroyer's metallic slats and retained the structural integrity of Asgardian alloy. "Marvel didn't want the metal to bend unrealistically," explained Vince Cirelli. "We solved that by coming up with two rigs: one that deformed like bending metal, and another where the slats were rigid and moved independently of each other. In the rigid rig, as Destroyer moved, each slat pushed the slats around it, causing hundreds of slats to move over the model. In shots where we needed a range of motion beyond the rigid model, we animated both rigs and blended the two caches." Animation supervisor Raphael Pimentel blocked out Destroyer's keyframe body moves, and then technical directors painted in slat deformations. "When Destroyer bent over, the rigid model worked for the chest, most of the thighs and butt. In the waist, however, slats inter-penetrated each other, so we painted a map that blended the rigid rig into the secondary rig and bent the metal in those areas."



The fight progresses to the Rainbow Bridge, where Loki confuses Thor by creating multiple images of himself. Ironhead Studios worked with the wardrobe department to build Loki's ornate armor pieces, and produced an elaborate horned battle helmet using lightweight fiberglass designed for model airplane construction. For multiple Loki passes, Tom Hiddleston took position on a platform affixed to a short length of dolly track and repeated his performance from different perspectives. BUF projected Hiddleston's image onto digital doubles and applied image processing techniques – including flickering vertical scan-line effects – then layered the characters into Rainbow Bridge extensions and cosmic vistas.

To simulate Destroyer zapping SHIELD agent cars, Daniel Sudick's team exploded full-scale automobiles on location. Luma generated energy beam and flame effects that sprang from inside the mechanical figure. "Fire peeked out through gaps between Destroyer's slats as he moved," said Richard Sutherland. "We cheated the size of the gaps relative to the distance to camera, so it always read that there was energy inside. Inside the model, we had a combination of lighting and reflections bouncing around, roiling up toward the faceplate." Effects artists tied Destroyer's energy beam into practical explosions using a variety of effects tools, including Sitni Sati Fume FX, Houdini and Maya.

Destroyer advances on Puente Antigua, a small desert town, and proceeds to wreak havoc, clashing with

Thor and his warrior friends. Production filmed the scenes at Cerro Pelon Ranch in New Mexico, where Bo Walsh and company renovated a standing set of an Old West town, originally constructed for the 1985 western Silverado. "The set had dirt roads and Old West saloons," stated Wesley Sewell. "Bo and his guys transformed it into something out of an Edward Hopper painting. They re-clad all the façades, laid down asphalt, put in sidewalks, streetlights, liquor stores and 7-Elevens and created a modern American small town."

The set extended three blocks with adjoining side streets. Dan Sudick and his physical effects team rigged exploding timbers, shattered windows, destroyed a gas station, tossed cars and tore long channels through asphalt to simulate the impact of Destroyer's energy beam. Luma extended street level views and aerial shots with 3D structures, and integrated Destroyer into on-set pyrotechnic effects.

With none of his godlike powers at his disposal, Thor faces Destroyer and addresses Loki, offering his own life in exchange for the safety of his human friends. Loki responds by ordering Destroyer to strike Thor, an act which sends him flying across the street. Chris Hemsworth's stunt double performed Thor's backward flight on a wire rig. Luma removed the rig through digital paint and reconstruction, and reset the stunt performer's arm to remove a reflex motion that was visible in the slow-motion footage. Luma then animated Destroyer walking out of town, its mission supposedly accomplished.

Thor's sacrifice, however, causes Mjolnir to break free of its enclosure in the SHIELD compound and fly into the young god's hand, resurrecting him. Luma generated a CG hammer with contrail effects for distant views of its blasting skyward from the crater and streaking toward Puente Antigua. For aerial shots of the hammer hurtling over the town, Luma generated 3D background plates from high dynamic range images of the set.

Magically rejuvenated in Asgardian attire, Thor swings Mjolnir above his head and summons storm clouds out of a clear sky. Luma generated volumetric renders of thunderheads and cast shadows across the town using digital paint and re-lighting effects. Clouds then swirl into a vortex that sucks up characters and debris. "We called it the "Thornado,"" quipped Vince Cirelli. Justin Johnson's digital effects team created volumetric particle effects of the swirling storm, layered over a three-dimensional rotating cyclorama of the town and sky. "Wes supplied us with high dynamic range images of the



At the climax of Thor's battle with Loki, the Rainbow Bridge shatters and Odin comes to the rescue, grasping his sons as they dangle over the abyss, while Heimdall's observatory falls away beneath them. Stunt coordinator Andy Armstrong and his team staged elements of Hemsworth and Hiddleston, and an Odin stunt double, suspended above crash mats on wire rigs. Special effects technicians used air movers to buffet Loki's cape, while the visual effects team affixed tracking markers to Thor's shoulders to assist application of a digital cape. BUF handled performer composites and digital wire removal, generated fragments of the glowing Rainbow Bridge jutting beneath Odin's feet, animated chunks of inert debris tumbling into the void, and the destroyed observatory, which breaks apart with interactive CG flames as it is consumed by a swirling cosmic event created from multilayered particle effects.



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set that we stitched together to create the background. We painted clouds into the sky and projected that onto geometry to create depth. We added cars and debris tumbling past. The storm then picks up Destroyer, who battles Thor hundreds of feet off the ground.”

Chris Hemsworth performed Thor’s closeups suspended against greenscreen and buffeted by air movers. Raphael Pimental’s animation team keyframe animated the Destroyer and, in more than 30 shots, made use of a digital double Thor. Closeups required high-resolution densities of voxel simulations layered behind characters, rendered with full stereoscopic depth.

Destroyer blasts Thor, but Thor deflects the beam with Mjolnir, sending destructive energy back at Destroyer and blowing it apart. “We used a CG Thor and hammer, and created a deflector shield of energy,” said Cirelli. “The simulation looked like an umbrella of fire, with blue and fuchsia God rays. As Thor deflects the energy, we generated closeups of Mjolnir pushing the fire back into Destroyer’s faceplate, melting it. Struts on the faceplate buckle, and the energy inside Destroyer spews out. It ends up with an effect like an atomic explosion. We generated a wide shot with a CG town and a huge shockwave, with everything then sucking back up into a center point, like a black hole.”

As the Thor’s energy dissipates, Destroyer falls to the ground. Luma’s digital modeling, effects and animation teams collaborated on Destroyer’s destruction, choreographing timings of metal ribs popping open, emitting fluid simulations, light rays and electrical energy. As Destroyer hits the earth, Luma generated a secondary explosion dislodging final vestiges of Asgardian energy from the mechanical creature.

In the final act of the film, back on Asgard, Thor meets Loki in a violent duel that destroys Heimdall’s observatory and ends with the brothers clashing on the Rainbow Bridge. Kenneth Branagh filmed portions of the fight on the bridge set, and stunt coordinator Andy Armstrong’s team staged performers tumbling through the air on greenscreen wire rigs. BUF generated environments and digital doubles. “We have a generic digital human that we adapted to the characters,” explained Pierre Buffin. “The underlying model had bones and muscles that we could animate. We rotoscoped characters from plates, and then projected photographic textures onto our model. Wherever we had actors performing the fight, we used that material as a texture and then modified the movement by keyframe animation when necessary. Some shots used complete digital doubles, but in those cases we always connected it to live-action by rotoscoping our CG double to the actor at the start or end of the shot.”

Inside the observatory, Loki causes Bifrost energy to erupt into tendrils of ice, forming a tree-like frozen structure. Production installed a translucent resin trunk to represent frozen energy on set. BUF extended roots and branches and, in some shots, replaced the tree with a CG version, re-lit to create more refractive lighting effects. BUF then generated destruction effects as uncontrolled Bifrost emissions cause the observatory to collapse and fall into a wormhole in space. “Our biggest challenge was to destroy the observatory and the Rainbow Bridge,” said Nicolas Chevallier. “Those shots involved simulations of water, fire, steam, rocks and metal. It was a real end-of-the-world effect.”

The film concludes with an epic shot that travels through the cosmos, revealing the Nine Realms among a tree-like cosmic structure known as Yggdrasil. “At one point earlier in the story, Thor draws Jane a picture in her notebook of what Yggdrasil looks like,” said Wesley Sewell. “That gives a hint of what we see in our end titles, where we travel from Earth to Yggdrasil to Asgard. It was a stunning minute-and-forty-second shot, generated at BUF.”

The cosmic journey involved a series of nested zooms and pullbacks that penetrate multiple layers of nebulae. “Our first challenge was scale,” commented Nicolas Chevallier. “We had to describe the shape of the universe in a brief amount of time while keeping scale realistic. Secondly, we had to deal with an apparently infinite 3D scene. It was very hard to visualize camera motion, so we used mathematical functions to describe the trajectory, trying to find a balance between handcrafted and procedural modeling. We also had to find effective color associations to light the different realms. We played with focal depth to give the impression of speed and scale, and created ‘temporal lens’ effects, where the viewer sees multiple places at the same time. We developed in-house rendering tools, an optimized stereo renderer and refinements for volumetric shaders to create different types of cloud effects. It was an incredible amount of work conducted by a large team, all working together to create the magic Marvel believed we could deliver.”

The epic saga contained 1,305 visual effects shots — approximately 70 minutes of screen time — not including stereo conversions, which more than doubled the quota, bringing to life one of Marvel’s most elusive icons. “It was pop culture with class,” declared Wesley Sewell. “I feel that our visual effects offered up an unusual amount of artistry in support of an imaginative story. All vendors who work in visual effects call their people ‘artists.’ On this film, it shows. The blend of realism and beauty was masterful, and seeing the film in stereo was like watching a theatrical play combined with the grand scope and subtle intimacies of cinema. It was a very enjoyable experience.”



After peace is restored to Asgard, the camera launches into space on a journey through the stars. BUF generated the end-title sequence, navigating through nebulae to arrive at a tree-like cosmic structure known as Yggdrasil, an elemental figure from Norse mythology that represents the network of the gods' Nine Realms. BUF developed its in-house modeling tools and volumetric shaders to produce computationally intensive particle simulations capable of emulating galactic scale and depth. Artists built cosmic structures using procedural and hand-modeling techniques, and manipulated focal depth to create the impression of traversing vast distances at faster-than-light speeds.

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Reality Deconstructed

image

article by
Joe Fordham

Shortly after receiving the British Academy of Film and Television Arts award for outstanding debut feature, for his science fiction drama *Moon*, filmmaker Duncan Jones began production on *Source Code*. The project arrived circuitously while Jones was pursuing a pet project, a futuristic thriller called *Mute* that he had been trying to launch for years. Among the actors Jones met with for that project was Jake Gyllenhaal. “We got on very well,” said Jones, “but Jake wanted me to read *Source Code*. It was almost identical to what had happened on *Moon* — I met Sam Rockwell about *Mute*, and I ended up writing *Moon* for him. I think I’m going to be offering *Mute* around for the rest of my life, ending up on other projects, instead!”

The *Source Code* screenplay, written by Ben Ripley, centers on Captain Colter Stevens (Jake Gyllenhaal), a U.S. Army helicopter pilot serving in Afghanistan who wakes on board a suburban commuter train trapped inside the body of Chicago businessman Sean Fentress (Frédéric De Grandpré). When the train explodes, Colter rematerializes inside an isolation chamber where an officious Air Force captain, Colleen Goodwin (Vera Farmiga), debriefs him as part of a secret military experiment, channeling Fentress’ final memories to seek out the perpetrator of the suspected terrorist bombing. Colter repeatedly explores the eight minutes preceding the explosion, searching for information that may prevent an imminent second attack, and develops an emotional connection with a fellow passenger, Christina Warren (Michelle Monaghan), who helps him piece together clues about his predicament and his own fragmented identity.

Duncan Jones and producing partner Stuart Fenegan were intrigued by the mind-bending premise, but chose to anchor the story in a recognizable reality. “We discussed going the *Minority Report* route of setting the story in a future environment,” Jones recalled, “but my impulse was to keep it grounded. I wanted to keep the science fiction elements conceptual, rather than throwing the audience into



In the sci-fi thriller Source Code, Colter Stevens (Jake Gyllenhaal) repeatedly experiences a terrorist attack on a Chicago commuter train – actually an immersive alternate reality that military scientists have generated from the memories of a man who died on the train. Director Duncan Jones joined the production following his debut feature Moon, and worked with visual effects supervisor Louis Morin, special effects supervisor Ryal Cosgrove and vendors based mostly in Montreal to generate train environments and re-create the explosion from a variety of perspectives, grounding the imaginative scenario in an everyday reality.



To create establishing views of the film’s main setting – a commuter train passing through suburbs toward downtown Chicago – the filmmakers worked with the city’s local rail authority, which allowed them to film

an alien-looking world, so we made it quite contemporary.” The original screenplay setting, on a commuter train heading toward New York City, was deemed inappropriate due to recent tragedies inflicted on the city, so Jones and production designer Barry Chusid reviewed other North American public transport systems, weighing the pros and cons of a number of city settings before finally arriving at Chicago and its MetraRail not long before the start of shooting. “I was very glad we ended up with Chicago, because I had spent a lot of time in the midwest, and I felt that Chicago was a bridging city that the whole of the U.S. could relate to.”

aerial views of a real locomotive traversing the Illinois countryside. The production utilized the footage both as reference and for background plates, and modified the dimensions and livery of the train to disassociate the commuter rail line from the fictional terrorist attack. Modus FX generated a digital model and replaced the practical locomotive and carriages in all exterior shots.

The filmmakers worked with MetraRail to plan establishing views of the train, but it quickly became clear that most train-bound scenes would have to be created by other means. “Our budget did not stretch to a practical explosion,” said Jones. “We discussed shooting train interiors for real, hiring some track, moving a train back and forth and shooting within that, but that was also impractical. Our cinematographer, Don Burgess, needed a repeating lighting scheme, and there were many other variables, so it was much more practical to shoot interiors on a soundstage set where we could repeat events.”

Jones planned a 25-day train interior shoot at Mel’s Cité du Cinéma in Montreal, working in close collaboration with visual effects supervisor Louis Morin and special effects supervisor Ryal Cosgrove. The 80-foot-long set contained a two-deck seating area and working parts salvaged from real trains mounted on a custom gimbal. “We decided that if we were going to live in a train in the studio for four weeks we needed to give the set some motion,” said Ryal Cosgrove. “We built a large steel truss and supported it on ten-inch-diameter air shocks. We placed those at ten-foot intervals to balance the two carriages. The doors alone weighed a couple hundred pounds, and the stairs were made of steel, so we had different weight issues at various parts of the set. Using multiple air shocks, we could raise the set about seven inches and then individually tune them to create whatever motion Duncan needed.”

To simulate lateral motions of the train starting and stopping, the mechanical effects team mounted the set on large steel rollers. “We put a couple of air shocks on a horizontal hinge,” Cosgrove explained. “We hooked that up to two large connecting rods, and then locked those down to steel plates in the studio floor. When Duncan wanted shunting motion, we could dial that in either as a manual override, or we could program a subtle constant motion back and forth. That way, the actors didn’t have to try to synchronize their reactions; they were all really feeling the train’s motion.”

The visual effects team surrounded train windows with greenscreen backings, which they planned to fill with location footage shot in Chicago. Having that pre-shot footage would have informed on-set lighting decisions, allowing the production team to set up interior lighting based on that in the exterior plates. A particularly harsh winter in Chicago, however, led the filmmakers to initiate studio photography prior to the background shoot — leaving them with the question of how to light the set without running into future trouble with their greenscreen composites.

Don Burgess devised a lighting scheme for the train interior using uniform illumination with minimal scene-specific lighting changes. Visual effects later strove to gather background plates, making sure that sunlight was above window level. Techniques for capturing the plates required extensive research. “My first idea was to develop a street survey technology similar to Google Maps,” Louis Morin recalled. “I didn’t find anything with sufficient resolution, so I wanted to develop a system with multiple still cameras, shooting high dynamic range images and stitching them together. That would have been a huge challenge, though, due to the time we had and the number of cameras it required.”

Executive producer Hawk Koch suggested an alternative motion picture camera array employed to capture virtual backgrounds for *The Fast and the Furious: Tokyo Drift*. The device captured a 150-degree horizontal field of view using three Arriflex 435s bolted to a custom camera mount, which special effects supervisor Matt Sweeney had engineered for visual effects supervisor Mike Wassel. “It was known as a Wassel Plate,” explained Morin. “It allowed us to very accurately lock down three cameras — a center camera, with two flanking, canted in at 20 degrees — on a MetraRail train. We removed security windows, put our cameras right up to the window frames, aimed the train towards Chicago and shot multiple passes — left and right, front and back — and repeated that for the upper deck. When we digitally stitched the plates together, it gave us 6K or 7K plates that we projected onto a cylinder, and we could warp and adjust those to whatever angles Duncan shot inside the train.”

Working with visual effects producer Annie Grodin, Morin planned a careful distribution of effects work among vendors. Rodeo FX handled the majority of greenscreen window composites, while Modus focused on creating 3D assets; and both shared assets with other vendors, including MPC’s Vancouver studio, which made use of Modus models for the film’s first train explosion. Oblique FX, Fly Studio and Mr. X rounded out the team in Montreal.

To film train interiors, the production triggered train motion and lighting cues manually. Ryal Cosgrove’s team worked with the grip department to create a windmill-like rotating ‘gobo’ flag to cast moving shadows on occasions when direct lighting interactions were required. The lighting plan was otherwise diffuse, aided by practical dirty windows. “Dirt was our friend,” remarked Louis Morin. “It gave us tracking points, and the physical look of real windows, which is often overlooked in greenscreen cinematography. Rodeo FX later created variations of light and shadow using a script that simulated interactive light, exposure and overexposure of backgrounds, and the level of dirt in 385 greenscreen window shots.”



For train interiors, production designer Barry Chusid built a two-carriage set on a soundstage at Mel’s Cité du Cinéma in Montreal. The set included working parts salvaged from real trains and a double-deck seating area mounted on a pneumatic gimbal platform that Ryal Cosgrove’s team engineered to simulate motions of the train, rocking the carriages and providing shunting motions. Visual effects surrounded the set with greenscreens into which they placed moving backgrounds, created from digital tiles of motion picture plates filmed using an array of cameras on board a real commuter train in Chicago.

Visual effects editor Emilien Lazon and Morin worked closely with film editor Paul Hirsch to make rough assemblies of the background footage against foreground plates. Rodeo imported footage into The Foundry Nuke and tracked exterior window views in 2D and 3D. “For complex shots following Colter through the carriage, we did camera tracks with 3D Equalizer,” explained Rodeo FX visual effects supervisor Sébastien Moreau. “We built basic geometry to help us position background plates with correct perspective, and then we studied the details of the footage to match that to the plate exactly in 3D.”

Rodeo generated 3D trees to simulate effects of daylight filtering into the carriage, and emulated moving highlights and shadows by roto-scoping portions of the plate. Rodeo Flame artists Ara Khanikian and Laurent Spillemaecher oversaw compositing, gauging exposure, color balance, motion blur and continuity. “We sometimes cut from a shot with a lot of dirt on a window to a shot that had no dirt at all,” observed Moreau. “We had to correct that by roto-scoping characters from the windows, taking out the dirt and putting in new dirt stolen from another plate or painted in to match.” For shots incorporating a passing freight train, Rodeo exported matchmove data to Modus, which generated the locomotive and then passed that data back to Rodeo for final composites.

Mr. X also created window composites in 148 shots for 11 sequences, using panoramic scenic backgrounds supplied by Rodeo and un-stitched background plates supplied by the production. Mr. X tracked imagery using Pixel Farm PFTrack and 3D Equalizer, and then exported data from Autodesk Maya into *Side Effects Houdini* to create animation and camera files for compositing in Nuke. Mr. X compositors followed Rodeo’s lead for lighting, finessing the interplay of light from shot to shot. “We came up with a system that allowed us to create a slight interactive flicker of sunlight,” explained Mr. X visual effects supervisor Wayne Brinton. “The background environments were most often trees and buildings, so we created mattes from those to block out the sun. We first dialed in the lighting so it was technically correct, and then we adjusted it to the mood of the scene. If we had a very tense moment, we didn’t want to cast huge flickers on an actor’s face as the train went past a line of trees because that would have been distracting. The light always had to be subtle and diffuse because the train windows were covered with a film that minimized the glare. So we applied diffusion on the windows and the characters. When the train passed by the trestles of a bridge, we created stronger flickering effects.”

One of Modus’ primary tasks was the creation of a digital commuter train — a General Motors diesel electric locomotive and six passenger cars — seen in all exterior views of the train. The Chicago railroad authorities allowed the filmmakers to film a real train as reference and for background



Cinematographer Don Burgess lit train interiors with low-key lighting and minimal moving light effects, allowing visual effects more control over the fluctuation of light across characters when inserting backgrounds into greenscreens outside the windows. Rodeo FX and Mr. X handled the window composites, digitally stitching together background plates, which they tracked into scenes using digital geometry of the train interior set to help position background plates with correct perspectives. Digital artists used 3D objects to simulate passing trees, and emulated moving highlights and shadows in train interiors by roto-scoping portions of the plate.

plates, but requested that the production modify its digital train to look somewhat different, so as not to connect MetraRail with a terrifying — if fictional — terrorist attack.

To capture aerial plates for shots of the train hurtling toward Chicago, Louis Morin and director of aerial photography Hans Bjerno filmed the real MetraRail train traversing Illinois countryside using a Pictorvision eclipse helicopter camera mount. Modus compositing supervisor Martin Larrivée and his team then digitally removed the real train from the terrain, tracked footage with Science.D.Visions 3D Equalizer, and rotoscoped any bridges, signals, trees or cables that overhung the track to enable them to insert the CG train.

Modus associate visual effects supervisor Eloi Brunelle and CG supervisor Mostafa Badran modeled the CG train from 2,747 3D elements. Modelers worked from hundreds of tiled textures derived from the train shoot in Chicago and a scan of the train interior set, executed by XYZ RGB in Montreal concurrently with the company's scanning of actors. "We wound up only using that as reference for the distance between seats," noted Modus FX visual effects supervisor Yanick Wilisky. "For the exterior, the art department gave us designs for the colors and the surface of the train. It was typical of the passenger trains in Chicago, with a reflective metallic surface, but the windows and doors were a few inches smaller. Most structural details came from the Internet and from blueprints."

The film begins on board the train where Colter wakes, confused and disoriented, as he notices his reflection as Sean Fentress — as other passengers perceive him — staring back at him from a train window and then in a lavatory mirror. Duncan Jones filmed Gyllenhaal's shocked reactions. Louis Morin then referred to playback of the performance to shoot greenscreen elements of Frédéric De Grandpré. For the window reflection, Rodeo digitally retimed and composited De Grandpré over the background, revealing Fentress as bridge trestles whipped by. For the lavatory mirror scene, Modus created a digital



During Colter's first experience of the fateful commuter train trip, the terrorist bomb explodes, ripping through a passenger carriage bathroom, tearing out the side of the train as it passes another express train, dislodging the commuter train from its rails and causing the flaming wreck to tumble across an overpass on the outskirts of Chicago. MPC generated the crash sequence based on an animatic, and using 3D assets of the train generated at Modus. The mostly virtual scene made use of full-scale practical pyrotechnic elements that Ryal Cosgrove's team staged in a quarry outside Montreal, and extensive location surveys and plate photography obtained in Chicago. MPC employed photogrammetry techniques to rebuild the environment, rearranging architecture for dramatic compositions. Effects artists adapted the digital train model using blend-shapes and retexturing techniques, and destroyed the train using real-time physics simulations, keyframe animation and fluid simulations of fire.



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head replacement, aligning De Grandpré's head to Gyllenhaal's body at his shirt collar.

Before Colter can get his bearings, an explosion rips through the train, causing carriages to tumble across an overpass on the outskirts of Chicago. MPC generated the eight-shot sequence based on Modus previzualization and a lengthy period of research

and development. "I went back to Chicago in postproduction to shoot plates for the moment just preceding the explosion," related Louis Morin. "That included footage of the superhighway on the left of the train and a location that Duncan had found on Google Earth of an iconic red-brick building where he wanted the explosion to occur. It was about four kilometers from downtown Chicago, with a view of the city skyline. We shot three versions of locked-off plates for Duncan to choose from, and then we modified that to match our animatic."

Modus generated 65 versions of the explosion animatic to explore the scene's dramatic impact. "The first explosion was our big set piece," noted Duncan Jones. "We didn't have a large number of action scenes, so this explosion was the opportunity to establish the scope and action credentials of the film."

To add photoreal elements to the largely virtual sequence, the special effects team staged full-scale pyrotechnics in a quarry outside Montreal. The visual effects crew used six motion picture cameras to capture elements of exterior explosions set off at the 60-foot-tall quarry wall, and also filmed explosions using a 70-foot-long black-painted set representing a dummy train car, providing MPC with elements of erupting smoke and flames as if seen from a bystander's point of view at street level, looking up toward the Chicago overpass where the explosion occurs.

For plate photography in Chicago, MPC visual effects supervisor Erik Nordby and visual effects producer Doug Oddy joined Louis Morin to gather photogrammetry surveys and HDRI textures of the location. "Louis had already shot a beautiful establishing shot approaching Chicago," related Nordby. "That clearly established the city skyline, superhighway and the monumental red brick building, which gave viewers something to spatially guide them through the chaos of the train crash. The red building was one interchange down from where the rest of the action was based, but it wasn't an overly complex building to re-create, so we set out surveying and photographing and shooting it."

MPC CG supervisor Geoff Pedder reseated the red brick building beside the scene of the disaster and laid out the action to the Modus previz. "The event had a chain reaction," said Nordby. "It started with an explosion in a passenger carriage midway in the train. The explosion blew up a tanker train next to that, causing the derailment of the passenger train. Modus provided us with beautiful pristine models of the passenger train and freight train, and an engine that we used for both. We created all the variations that we needed to destroy them using blend shapes and re-texturing."

The explosion utilized MPC's destruction toolkit — based on Pixelux Entertainment's Digital Molecular Matter real-time physics simulation engine — and keyframe animation overseen by animation lead Daryl Sawchuk. "Blocking out the action was somewhat like a math puzzle," said Nordby. "We had a passenger train traveling in one direction and a freight train traveling the other.

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We identified the carriages' positions by working back from where the train had to end up in the middle of the intersection. And we knew the relative speed of the trains. From Google Earth, we calculated distances between buildings. That allowed us to figure out where the event had to start. We then drew in everything in between and art directed the beats within each shot."



After the explosion, Colter experiences a flash of light and abstract disorienting effects of swirling imagery that transport him into an isolation chamber – or ‘pod’ – where military operatives debrief him, gathering information gleaned from his experiences within their immersive re-creation of the train crash. The production designed the pod interior to reflect the polygonal nature of computer simulations, combined with the feel of a helicopter cockpit. Fly Studio generated effects of Colter dematerializing, traveling back and forth between the train and pod, using geometric graphics inspired by Impressionist art, point cloud data and polygonal meshes.



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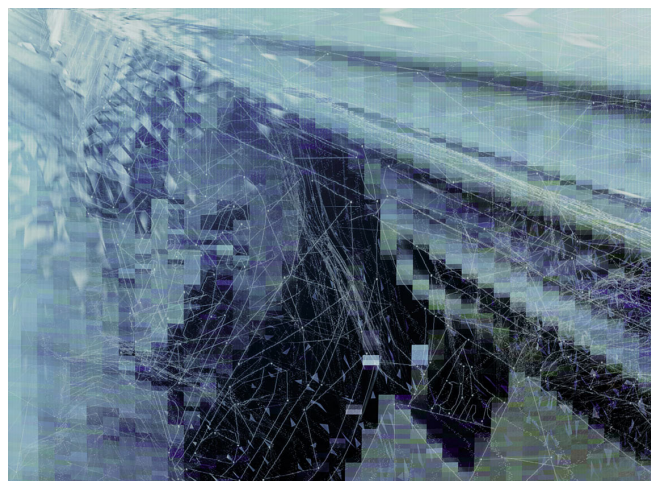
The fragile nature of the passenger train's aluminum superstructure presented problems of scale. "Ninety percent of the train's weight was in its foundation," noted Nordby. "We found that if we adhered to natural physics, the train just didn't have the weight we were looking for. We studied footage of real passenger train wrecks, but even real trains seemed to crash in an odd manner. The engine was basically one big block of iron and steel — so that behaved how we expected in terms of high-end physics — but carriages just crumpled. It took a while to make the crash feel real."

MPC compositing lead Arek Komorowski sampled pyrotechnic elements in wide shots of the crash. For closeups of fire interacting with the moving trains, MPC made use of Flowline fluid simulations and balanced brightness of flames and reflectivity of the passenger train in the sunlit environment. Compositors added lens dirt, lens flares, flying debris and camera shake, and then applied final tweaks to guide composition. "There was so much information going on in approximately 250 frames," Nordby explained, "the first time we screened the sequence, people couldn't tell what they were looking at. So we did another pass about two weeks before final — applying color correction and dropping contrast levels here and there so the eye could relax and know where to look — and that gave it focus. It was a massive endeavor for eight shots."

After the explosion, Colter finds himself in a high-tech isolation chamber surrounded by computer monitors. Barry Chusid designed the set — known as the 'pod' — to resemble a Sikorsky UH-60 Blackhawk cockpit, and incorporated a motif of triangular wall panels that tied into the virtual world. "Barry Chusid and I were talking about how 3D artwork is built out of polygons," recalled Duncan Jones. "We thought it would be interesting if the pod's shape referenced that; and so, even though it was an actual physical object, it had this polygonal build. We expanded that idea into the postproduction design when Colter is transported from one environment to another. We



For transitions back into the train, Fly Studio reconstructed the environment as if assembling the image from a jumble of computer code. In a rare use of a real train exterior, Louis Morin suspended a motion picture camera in front of a train carriage to capture a dynamic angle of the train's wheels hurtling over the tracks. Fly mapped the plate with 3D mesh and polygonal objects mixed with jagged artifacts that emulated the pixilation of a glitching video conferencing link. Artists keyframe-animated jittering mesh motion, and used dynamic simulations to animate polygon streams.



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used a polygonal motif as part of the *Source Code* because of the virtual nature of what he is experiencing.”

As Colter dematerializes back and forth between the train and pod, he glimpses subliminal fragments of the *Source Code*, a quantum physics re-creation of divergent parallel time streams that manifests in blossoming light effects, and abstract swirling and distorted images of Colter and Christina. Jones and his team based the *Source Code* on a variety of concepts, from animated point cloud data to Impressionist art. “We looked at a period of Picasso’s paintings known as ‘abstract synthetism,’” revealed Louis Morin. “Duncan was really pleased with that idea, so we explored that avenue and worked in ideas of the triangular motif. Oblique FX did some early code concepts in preproduction, and then we brought the work to Fly Studio, with whom I’ve had a very creative relationship on feature films for the last five years.”

Fly generated *Source Code* transitions referencing 1920s Cubism. “It was a little like Marcel Duchamp’s *Nude Descending a Staircase*,” noted Fly Studio visual effects supervisor Jean-Pierre Boies. “We were depicting multifaceted images of a scene, a deconstruction of reality. When the train explodes and Colter arrives back at the pod, he experiences a flash-forward, where it’s not clear if it’s his memory coming back, if we are seeing images from his imagination, or another reality. The production provided us with edits of images and we played with how much we revealed in cross-dissolves and refractions, adding more distortions and light effects in later transitions.”

For transitions from the pod back into the train, Boies and his team used Maxon Cinema 4D to create animation of triangular polygons that cross-faded with effects that were generated in Adobe After Effects and composited in Nuke. “Once we created our recipe for that family of transitions,” said Boies, “we repeated the pattern with slight variations. One establishing shot — looking over a lake, moving towards the train — was repeated two or three times. We used a Modus composite of the CG train as our template for that and kept the pattern of construction and deconstruction pretty much the same.” For more aggressive disintegrations, Fly fragmented Colter’s image with angular jagged facets. “We built a triangle mesh of Jake in Cinema 4D. When he made a sudden move, we broke apart the mesh, tri-angles flew apart and the mesh took



On his second trip into the *Source Code*, Colter follows a passenger he suspects may be the bomber and disembarks at a suburban railway station. Two weeks before shooting railway station scenes on location at a train station in Canada, a logistical complication caused the production to rethink its plans and Barry Chusid’s team to build a partial set in a parking lot in Montreal. Ryal Cosgrove’s team installed a portion of track on which was mounted a segment of the train, and Louis Morin made plans with Modus to place strategic greenscreens around the set to assist with digital set extensions. Modus later added a second story and clock tower to the station building, together with a digital train and extensive environment enhancements. Embellishments included a parking lot, adjoining highway, distant downtown Chicago, and vegetation suggestive of Illinois woodland in the early morning sun.



on a life of its own. We used a little bit of dynamics, with textures of the scene projected onto the mesh, and then we mixed in light effects and video glitches.”

Back inside the train, Colter identifies a passenger, Hazmi (Cas Anvar), whom he suspects may be the bomber, and follows the unsuspecting man off the train and into a suburban railway station. The production initially chose a location in Ottawa for the fictional Glenbrook Station, but a logistical complication caused the filmmakers to relocate two weeks before shooting. “Barry Chusid built a Chicago train station in a parking lot in Montreal,” revealed Louis Morin. “We digitally extended the station’s upper level and went completely virtual for all the backgrounds. In every shot, everything beyond the platform was 100 percent virtual, created at Modus.”

To shoot practical portions of the train gliding in to Glenbrook and passengers disembarking, the physical effects team constructed a portion of a moveable train carriage that actors could ride. “We dismantled the section of the train that we had at Mel’s,” related Ryal Cosgrove. “We took the doors, stairs and the entrance, and stuck them on a truss. We welded up some rails, mounted the whole thing on steel casters with a couple of air shocks to give it bounce, and set it on the rails. We hooked up a huge cable, ran that around a few pick-points to a big pickup, and pulled the carriage up and down the tracks. It looked quite odd as it rolled up. Jake would get out and there would be no train there, except the doors.”

Under Louis Morin’s supervision, grips mounted greenscreens around the train doors and at the end of the platform. Modus extended the rest of the train, retaining the doors and a portion of the interior, which they digitally re-lit to counteract daylight inside the roofless train carriage set.

For the surrounding environment, Modus generated woodland and the distant city using data from United States Geological Survey digital elevation models. “We looked at terrain data and point cloud data of Chicago,” explained Yanick Wilisky. “That showed us which way the city was facing in relation to the early morning sun and Lake Michigan. We worked out that the city was eight kilometers from the station and re-created that environment, including a lot of native Illinois trees, 14 cars, and the station roof. Once we integrated those assets, we could generate backgrounds in any direction.”

Colter realizes he has cornered the wrong suspect when an explosion erupts from *The Departed* train and a smoke plume appears in the distance. Modus composited a full-scale pyrotechnic element generated in the Montreal quarry. Colter then scuffles with the offended passenger, falls onto the tracks and is hit by a freight train. For Colter’s fall, Ryal Cosgrove’s team created a silicone rubber section of railroad track, molded from real rails and painted to resemble steel. The production dressed the dummy rails into the location on top of crash mats and backed it with greenscreen. Cosgrove added fake gravel between railroad ties that consisted of cork sprayed with adhesive and

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then rolled in concrete dust, which Gyllenhaal dove onto. Modus then added a digital onrushing locomotive, which cut to black on impact.

Back in the pod, Colter snaps awake, shivering with cold as the isolation chamber takes on a more sinister aspect. “Colter first believes he is inside a structure that has some kind of coherency,” explained Duncan Jones. “That’s why we designed the pod to resemble a helicopter cockpit. It’s a small, intimate environment where he has this bright white screen in front of him that he can’t really see through. Over the course of the film, that environment starts to expand around him.”

Barry Chusid built three versions of the pod, the second being more spacious and in disarray. Fly Studio then added frozen breath using 2D filmed elements. “We spent two hours in a -16 degrees Celsius freezer — and we were wearing shorts!” remarked Jean-Pierre Boies. “We had a black backdrop, one spot lamp and a Canon 5D camera, and we re-enacted Jake’s breath just from video reference. We tested different angles of backlighting, trying different timings and orientations. The scene in the pod was a very tight shot with a moving camera, and I was concerned how the breath would track when Jake moved his head. But our 5D elements were so successful, we ended up using them in the movie.”

Goodwin explains the importance of Colter’s mission by revealing television footage of panic caused by the threat of a second terrorist attack on Chicago. Louis Morin’s team shot plates of helicopter footage and high-rise rooftop perspectives in downtown Chicago. Mostafa Badran’s CG team at Modus then created 3D models and integrated Massive simulations of 600,000 citizens. “Three of our animators developed different crowd behaviors,” said Yanick Wilisky. “Massive did the rest. We choreographed traffic jams, people fleeing buildings, taxi boats on the lake. We digitally removed any real cars from the plates, but they were useful size and lighting reference; and then we did a lot of roto to layer the crowd behind cables and buildings. We



To film scenes of passengers disembarking and boarding the train at the station, the production reused a portion of the train interior set, which Ryal Cosgrove’s team mounted on a truss that rode along rails parallel to the platform set. Technicians hauled the set piece along the rails using a cable attached to an off-camera pickup truck.



Louis Morin supervised placement of greenscreens on either side of the train doorway, which flanked Colter and a fellow passenger, Christina Warren (Michelle Monaghan), as the train rolled to a stop and characters stepped off onto the platform.

really pushed the envelope with detail because we didn't know if, at the last moment, they might need to make a full shot out of the footage."

Colter returns to the train and attempts to examine the bomb in an air vent above a passenger lavatory, but a train conductor apprehends him and handcuffs him to a handrail, forcing Colter to witness the explosion as fire erupts around him and Christina. "I wanted to show the repetition of the explosion from different perspectives," related Duncan Jones. "Colter was in a different mindset each time, so visually each event had a very different feel. As Colter starts to generate his relationship with Christina, he's quite mournful and there is a sense of loss during what we called the 'poetic explosion.' We played that in slow motion, showing the fireball traveling towards Colter and Christina with a very beautiful look and feel. Then we had some later explosions where Colter is almost being tortured, which were quite nightmarish and aggressive."

For the poetic explosion, Ryal Cosgrove's team created a highly detailed pyrotechnic element. "I wanted to make the fire behave in a way that made it appear as if it was intelligent," remarked Louis Morin. "Don Burgess was familiar with that concept from his work on the movie *Backdraft*. We did a similar sort of effect using inverted fire. We built a vertical train carriage, full size, with seats and dummies inside, and mounted that with a camera on a crane looking down through the set. As the fire emitted, it rose up toward the camera."

The production generated the explosion by upending the 70-foot-long black buck set of the train carriage in the Montreal quarry. Effects technicians applied fire retardant gels to the interior carriage walls and installed 30 urethane foam dummies fireproofed with a sodium silicate solution, fire retardant suits and BlackWrap covering dummy heads to permit multiple takes. The nine-person pyrotechnic crew included one of the masters of the craft. "Joe Viskocil and I had last worked together on *Journey to the Center of the Earth*," said Ryal Cosgrove. "Joe had done some volcanic explosions for that using benzoyl peroxide. He's a real expert with that stuff. He knows exactly what quantities to use to make beautiful reds, darks and blacks, which look great in slow motion, with very little yellow, which tends to burn out. So we used that for our train explosion. We cut a large 'X' in the base of the set, and shot the benzoyl charge up through the train."

Louis Morin photographed the pyrotechnic effect with a Vision Research Phantom HD Gold camera shooting slow motion, 1,000 frames per second. To create interactions of flames engulfing Colter and Christina, the production placed black-painted pyrotechnic dummies in poses representing the characters' positions, kneeling in the train carriage vestibule. Back in the soundstage set, Duncan Jones filmed Gyllenhaal and Monaghan reacting while effects technicians buffeted the actors with air movers. Oblique FX then created digital doubles from scans of the actors, and integrated the characters into the flames using elements of the black-painted puppets set aflame. "There was



To complete the illusion of the train arriving at the station, Modus tracked its digital train exterior to extend the practical portion of the set beyond the train carriage doorframe, and added additional train cars and the engine further down the track. The transition from the practical set piece to the platform required each character to be rotoscoped and digitally relit to compensate for daylight that spilled into the roofless train carriage set. Modus then added reflections of the environment in the metal and glass surfaces of the train.

quite a good relation between the actors and their pyrotechnic puppets,” observed Oblique visual effects supervisor Alexandre LaFortune. “That was an issue for Louis, whether he should use puppets to represent Colter and Christina in the set or not. We knew they wouldn’t perfectly match because the puppets weren’t moving and the actors were, but it was manageable. We did a few morphs and alignments, and the puppets gave us good interaction for when fire hit the characters. It really felt like they were in the plate.”

Poetic explosion composites required approximately 500 man hours of labor over three months, and included a speed-change to accelerate pyrotechnics to an equivalent 300 frames per second. Oblique rendered digital light interactions in Solid Angle’s Arnold, with CG particles representing flying embers and additional pyrotechnic flame elements, but no CG fire.

The graphic nature of the inferno was pushed to its limits in a subsequent sequence in which Colter repeatedly witnesses Christina’s immolation. Ryal Cosgrove’s team used an air mover, fitted with a snoot, to direct blasts of air at Monaghan’s hair and cheeks. Rodeo FX then blended the actress with footage of a burning buck pummeled by fire. “We wanted to avoid an NC-17 MPAA rating,” commented Louis Morin, “so we had to find a way of representing burning flesh that was believable, but poetic. We made it look like cracked paint, darkening it to a degree, so it looked photoreal but not photoreal gory.”

Fly Studio then added jagged transitions in and out of the Source Code. “We stabilized Michelle in the production footage,” commented Jean-Pierre Boies. “We tracked her shape, ‘triangle-ized’ the polygons and mapped on a texture that simulated a Skype video glitch. We didn’t feel that was working with the action, but we liked the feel of the glitch, so we tried adding wire-frame effects and extruding polygons. Duncan responded well to a few frames of that, so we experimented with keyframing it manually, making the image break apart, freeze, then flicker back to normal. We manipulated the 3D model in Autodesk XSI, animated polygons to vary in size, and localized the effects so for a few frames we’d see big triangles in Christina’s face and she would lose an eye. We also reversed the lighting here and there, using flat shading, normal shading, and different types of layering.”

As Colter becomes fatigued, the pod transforms once again. “Colter ends up in a large and very vertical environment,” observed Duncan Jones. “At that point, the pod environment is supposed to resemble a medieval prison cell with a window up at the top throwing light on him, like something



Back in the pod, Colter learns the gravity of his situation when his military advisor, Colleen Goodwin (Vera Farmiga), explains to him that the explosion on the train is a re-creation of a real and recent event, suspected precursor to an imminent terrorist attack on Chicago, which TV news reports reveal to be in a state of panic. To create scenes of a mass exodus from the city, the production filmed aerial and rooftop views of downtown Chicago. Modus generated 3D models of the environment and integrated throngs of citizens and gridlocked auto traffic using Massive artificial intelligence crowd simulations. Modus rendered the shots at full resolution – including multiple automobiles, pedestrians and water taxis on the Chicago River – to allow the production maximum flexibility in using them. Ultimately, however, the footage was featured only on computer monitor inserts in the pod.

out of an old Errol Flynn movie. Colter ends up thinking of himself as being in a kind of virtual prison.”

For the transition to the final-stage pod, the production filmed Gyllenhaal against greenscreen on a rotating chair. Fly Studio then generated an unfolding mechanism to blend between the sets using a 3D model derived from detailed photographs of the set, and high dynamic range images of Pods Two and Three. Fly experimented with unfolding the walls like an origami puzzle, but ultimately opted for a subtler illusion of expanding scale. “Duncan didn’t want an obvious multiplication of panels,” said Jean-Pierre Boies. “The effect was more like being in the center of an expanding sphere. That was tricky to convey because the room was complex in its design, with the camera moving around Colter and pulling back.” Fly generated the expansion by tracking control panels to the motion of the pod walls, which provided a frame of reference as the chamber reconfigured.

Colter returns to the simulation and pursues his latest suspect by pulling an emergency brake in the train and leaping out onto Glenbrook Station where the camera follows him as he rolls to a stop. Jones filmed the scene in two parts, beginning with a camera pursuing Gyllenhaal to a train carriage vestibule and then pulling out to frame him in the open door. Visual effects then planned to hook into a digital double, picking up on Gyllenhaal tumbling to a halt on the platform set. Action with the star was a one-shot deal. “Jake had shoulder problems at the time,” recalled Louis Morin. “We didn’t want to risk losing him to an injury, so the producer asked us if we were okay with take one — and then that was it!” To create the illusion of one seamless shot — following Colter out the train, landing hard and recovering — Duncan Jones referred Morin to digital human dynamic simulations. “Duncan had been impressed with Natural Motion’s endorphin, a procedural software that The Mill had used to simulate falling bodies in its TV commercial work. We ended up experimenting with the software and Oblique ran some tests while we were still shooting. That turned out pretty well, and we developed an idea to use endorphin as a first pass, then correct what we needed in the simulations.”

Gyllenhaal submitted to XYZ RGB scans and photographic studies of facial expressions for Colter’s leap. Oblique’s additional visual effects supervisor, Pierre-Simon Lebrun Chaput, then used endorphin to create animation of Colter’s jump using a digital double. “We had to match the speed of the camera moving around Jake as he exited the train,” commented Alexandre LaFortune. “Then, as the train accelerated away, we had to slow down to follow Colter tumbling, ending back on the exterior shot of Jake. We took our 3D asset between two different lighting scenarios, from the interior to the exterior, transitioning from the moment his feet touched the platform.”

Oblique technical director David Raymond generated the exterior environment using Modus assets of Glenbrook. Artists used PFTrack and Andersson Technologies SynthEyes to track plates, and then translated endorphin data to XSI to develop keyframe animation and secondary movement. “Duncan didn’t want the motion to be completely realistic,” observed LaFortune. “It was more like a character in a videogame — more violent than reality, but with realistic cloth simulations. We then applied motion blur and, at the end of Colter’s roll, we did a quick wipe over three frames back to the real Jake.”

Colter follows his suspect (Michael Arden) to the Glenbrook parking lot, where he discovers an Econoline van containing a small footlocker and ramshackle machinery resembling nuclear hardware. The production filmed the scene using a relatively innocuous prop. “It was a small box decorated with a patriotic flag,” explained Louis Morin. “It was based on a true story of an incident in Chicago, where a guy collected a lot of irradiated material and built himself a ‘dirty’ bomb. When Duncan reviewed the scene with his editor, Paul Hirsch, they decided they wanted a much more powerful visual. They asked us to fill the van with a huge amount of gear that looked like it was connected to the bomb.”

Oblique provided conceptual art of the van contents. Pierre-Simon Lebrun Chaput then oversaw construction of CG racks filled with detonators, explosives, wires and Geiger counters in 39 shots. “The bomb had to fill almost half the van,” commented Alexandre LaFortune. “We rotoscoped characters wherever the bomb was behind them, or in front of them, then rendered beauty passes, reflection passes, and completely filled the empty van.”

Colter’s attempt to apprehend the bomber goes tragically wrong and the bomb in the train detonates again, revealed in a roving shot that enters the train lavatory then pulls back through slats in an air vent to a closeup of the detonator. Fly Studio generated the shot from two live-action plates. “They shot the pullback with and without the vent,” explained Jean-Pierre Boies. “We tracked



During a later excursion into the Source Code, a train conductor handcuffs Colter to a pole as a result of his erratic behavior, forcing him to experience the recurring explosion as it engulfs him and Christina. Duncan Jones sought to portray the scene as a ‘poetic explosion,’ underlining a growing connection between Colter and Christina, and filmed the encroaching fire with the camera peering through a black buck railcar set that Ryal Cosgrove’s team inverted in a quarry.



The set’s vertical orientation allowed fire to rise toward camera, swallowing black-painted pyrotechnic dummies representing Colter and Christina, providing the interactive effects of fire wrapping around characters.

the plate in Vicon boujou, rebuilt the vent in XSI and matched and warped the two shots to make a seamless move.”

Back in the pod, Colter provides Goodwin with information to identify and capture the bomber, but confronts her with a dawning realization that he is, in fact, clinically dead in the aftermath of his helicopter’s being shot down in combat. Defying orders, Goodwin allows him one last trip into the *Source Code* to make peace with Christina. Goodwin then pulls the plug on Colter’s mortal remains, which are finally revealed in an adjacent life-support chamber as a severed trunk and head — filmed as an in-camera animatronic effect. “I felt it was important to use a practical effect for Colter’s body,” remarked Duncan Jones. “It affected Vera Farmiga’s ability to engage and emote. And when it came down to budget, so many issues came up — Jake’s availability, housing and transportation — the practical route was the most cost-effective.”



To create the foreground element of the poetic explosion, Jones filmed Monaghan and Gyllenhaal kneeling in a replica of the train vestibule set, backed by greenscreen, while effects technicians used air movers to simulate the effects of the on rushing wall of fire displacing the actors’ hair and clothing.



Oblique FX integrated characters into a 3D re-creation of the train carriage, together with the pyrotechnic element. Digital artists adjusted the speed of the fire, rendered the scene with volumetric lighting effects, and made subtle digital tweaks to align elements, but relied on practical elements for the visceral flame effect.

To create the animatronic likeness, the filmmakers commissioned a Montreal artisan with a long history of photorealism in prosthetic likeness dummy heads. “I made my first dummy head when I was 12 years old,” stated makeup effects designer Adrien Morot. “For the past ten years, I have been asked to do tons of fake heads and dummies. We got pretty good at it, and there was a period of three years where that’s almost all I did. So I have an extensive portfolio of very accurate actor look-alikes. I brought that in to show Duncan’s production manager, and they were impressed. My crew was thrilled to hear we were creating the punchline of the movie, but then I started to think, ‘I really hope this works!’”

The makeup effects team prepared a rigorous lifecasting procedure. “People are often not cautious enough about the effects of gravity during lifecasting,” observed Morot. “Very often a thick layer of water-filled alginate impression material will drag down the skin and affect the final likeness. In this case, we knew that Jake was going to be lying on his back, and I didn’t want to use any alginate. We ended up having Jake lie in his position for the scene as we applied very thin coats of silicone directly to his skin and put thin strips of plaster bandages on top of that to keep the shape. Then, from those molds, we poured the head in clay and the body to the waist in plaster.”

Lead lab technician Mark Unterberger oversaw casting of platinum gel silicone skins, while Morot and prosthetic artist Michel Bougie oversaw cosmetic finishing based on extensive reference. “We took a lot of photos and color samples for skin and hair,” related Morot. “We shot video of Jake acting his dream state, with closeups of his eyes and face moving. I wanted to make sure that we could mimic his authentic movements as closely as possible.”

Articulation required many layers of detail based on art department concepts for a trunk with exposed internal organs and bones. Morot generated



Returning to the Source Code, Colter becomes desperate in his pursuit of another suspect and leaps from the moving train to land heavily, tumbling and rolling but somehow surviving a crash-landing on the station platform. The production first filmed Colter’s leap with Gyllenhaal on a soundstage set, where the camera pursued the actor inside the train carriage, swung around him in the vestibule and then backed out through the open doors to view Colter jumping from the doorway. For the middle portion of the shot, seamlessly connected, Oblique FX animated a digital double using a combination of keyframe animation and procedural dynamics of a human body tumbling across the platform at high speed. Oblique artists then tracked the bridging animation into a second plate of Gyllenhaal rolling to a stop on the platform set, adding a digital train exterior and environment extensions to complete the shot.



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Photoshop renderings to refine the concept. “I felt the medical team would have closed up Colter’s extremities after his helicopter crash,” said Morot. “We kept the end of the spine exposed, as in the original design, but we added a plastic dome that covered his organs, so his injuries were visible — but all encased in a translucent life-dome with condensation from the humidity of the body.”

Returning to the Source Code, Colter had come to a decision in making a digital train exterior and environment extensions to complete the shot. He had a vision of a train arriving at the station platform, and the production of a digital train exterior and environment extensions to complete the shot. He had a vision of a train arriving at the station platform, and the production of a digital train exterior and environment extensions to complete the shot. He had a vision of a train arriving at the station platform, and the production of a digital train exterior and environment extensions to complete the shot.

Unterberger’s team molded the final sculpt of Colter’s head and torso to create a core and exterior skin. Moldmakers took snap molds of the core, which prosthetic artists used to sculpt innards. A plastic medical model served as the basis for a mechanized spine, designed to twitch. Other artists created kidneys, liver and intestines by fabricating gel-filled shapes from clear polyethylene trash bags. Colter’s heart was sculpted, molded and cast in silicone, with two latex bladders fitted inside to provide heartbeat motion. Lungs were sculpted silicone shapes fitted over a mechanical diaphragm that inflated and allowed the chest cavity to expand. To articulate Gyllenhaal’s facial twitches, Morot collaborated with prosthetic artist Bruno Gatien to machine aluminum parts. Broader head motions and arm-stump movements were cable controlled, while fine-detail eye motions and Adam’s apple articulation were radio controlled.

Artists fitted mechanisms with highly plasticized skins that averaged a quarter-inch thickness, with a half-inch thickness over the abdomen, and more resilient undiluted silicone in the nose and cheekbones to represent cartilage. Michel Bougie airbrushed coloration and hand-painted details. Lead hair artist Kathy Tse then spent a week and a half hand-punching hairs into the skin of the torso



Colter and Christina enjoy an idyllic stroll through downtown Chicago where the two pause before a large metallic sculpture. Duncan Jones filmed the scene on location in Chicago’s Millennium Park, with principal performers standing before a large modern-art fixture that distorted their reflections. Fly Studio performed digital rig removal to eliminate unwanted reflections of passersby and camera crew, and added a greenscreen reflection element of Sean Fentress (Frédéric de Grandpré), the deceased commuter whose memories Colter has inhabited during his forays into the Source Code.



Colter and Christina enjoy an idyllic stroll through downtown Chicago where the two pause before a large

and head, using ultra-thin needles dipped in liquid silicone.

On the final day of shooting, Morot's team installed the puppet into Colter's life-support chamber, with five puppeteers operating mechanisms through the wall of the set, while Gatien and Morot handled radio controls. "They were able to make the lungs breathe, the jaw chew and the eyes move

underneath the eyelids," said Duncan Jones. "We had some closeups where you might wonder why we didn't shoot with Jake, because we were full-frame on the puppet. I have to say, if I'd had the time to shoot more with the puppet, I would have. It was an incredible piece of work."

Back in the *Source Code*, Colter surprises Christina with an impulsive kiss, and time appears to freeze as the camera pulls back through the train carriage. Jones filmed the time-freeze by simply asking performers to hold position as the camera jibbed back. Fly Studio inserted frozen details. "We added the passing freight train on one side and a highway with cars not moving on the other," said Jean-Pierre Boies. "We fixed a few passengers who were moving — one guy with his arm up was moving a little, and one or two characters were blinking — and then we added rays of sunlight with little bits of suspended dust, and someone on the upper deck dropping coffee from a cup, frozen in midair."

Colter and Christina decide to take the morning off to walk through Millennium Park, where they are reflected in a modern art sculpture — Anish Kapoor's 66-foot-long stainless steel Cloud Gate, colloquially known as the 'Bean' — bringing to fruition an image glimpsed repeatedly in Colter's memory flashes. "The 'Bean' is a miraculous sculpture that people in Chicago have seized upon as a landmark," observed Duncan Jones. "Few people in the rest of the U.S. might know about it, but I thought it was extraordinary looking, and I felt the idea that the reflections seen in it were all twisted was a perfect metaphor for the film." Jones captured shots of Gyllenhaal and Monaghan conversing at the base of the sculpture. During a visual effects shoot in Montreal, Louis Morin filmed Frédéric De Grandpré against greenscreen repeating Colter's actions. Fly Studio composited De Grandpré into the production plate, revealing Colter's *Source Code* alter ego reflected in the sculpture's surface, and performed digital removal of the camera rig and bystanders.

Containing more than 850 visual effects shots, the taut and gripping thriller was realized with economy, wit, and a keen eye to technique. "Duncan has accumulated a lot of knowledge from his commercials and from *Moon*," noted Louis Morin. "He has a very vivid mind, and he was a good partner with visual effects. He challenged us to make effects invisible when they needed to be, and showy and artistic when it was appropriate. The effects were there to support the story, so people could enjoy the film without asking, 'How did they do that?' You might only think that after you have seen the movie for a second or third time."

For the director, the production marked a step into mainstream Hollywood and a stepping-stone toward future genre fare. "I chose to make *Source Code* because I had been reading a huge number of scripts and not many of them talked about this kind of subject matter," remarked Duncan Jones. "It was immediately appealing. And then, of course, the fact that Jake was involved was a huge draw to

metallic sculpture. Duncan Jones filmed the scene on location in Chicago's Millennium Park, with principal performers standing before a large modern-art fixture that distorted their reflections. Fly Studio performed digital rig removal to eliminate unwanted reflections of passersby and camera crew, and added a greenscreen reflection element of Sean Fentress (Frédéric de Grandpré), the deceased commuter whose memories Colter has inhabited during his forays into the Source Code.

me. I can't wait to be able to start talking about my third film. It's something I have written — not Mute, but it is sci-fi — and it's going to blow your mind!"

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Holy Warriors

image

article by
Jody Duncan

Priest, a science-fiction thriller directed by Scott Charles Stewart, is Hollywood's adaptation of a Korean graphic novel series by Min-Woo Hyung. The film tells the story of an alternate, post-apocalyptic reality in which centuries of war between man and vampires has left the world a downtrodden, inhospitable place where people have barricaded themselves against the vampire threat in industrialized, walled cities ruled by the Church and its class of warrior priests. When his niece, Lucy (Lily Collins) is kidnapped by a band of vampires, one such priest (Paul Bettany), ventures outside the city and into the vast war-torn wasteland to confront the murderous creatures and rescue the girl. Lucy's boyfriend, Hicks (Cam Gigandet), a young wasteland sheriff, and a former warrior priestess (Maggie Q) join Priest on his mission to find Lucy and, together, they succeed in stopping an invasion of the walled cities by the vampire army.

The film's vampires and otherworldly city and wasteland environments would require top-of-the-line visual effects, overseen by visual effects supervisor Jonathan Rothbart, with whom Scott Stewart had founded the production and visual effects company The Orphanage, now closed, in the 1990s. The duo divided approximately 800 shots among effects facilities on three different continents. Tippett Studio and Spin VFX took on vampire animation, while vendors such as Spy, Gradient Effects, Svengali FX, Zoic Studios, Iloura and The Senate executed digital set extensions, CG environments and other effects. In addition, Kerner Optical contributed miniature effects for one key sequence, and KNB EFX Group fashioned vampire creature suits, makeup effects and dummies.

Having emerged from the visual effects arena, Scott Stewart fully grasped just how judiciously effects shots would have to be planned and executed if they were to be realized on the film's modest budget. To nail down concepts, Stewart and Rothbart engaged Pixel Liberation Front to previz the show's three main effects sequences, even as they threw around



A Korean graphic novel series provided rich source material for the science fiction thriller, Priest, directed by former visual effects artist and Orphanage co-founder Scott Charles Stewart. In the film, centuries of apocalyptic violence between man and vampires has created a war-torn world in which populations seek shelter within industrialized, walled cities ruled by warrior priests. The story centers on one such priest, played by Paul Bettany, who braves the hostile world outside city gates when vampires kidnap his niece, Lucy.



Visual effects supervisor Jonathan Rothbart oversaw the creation of vampires and environments in 800 visual

design concepts for the vampire antagonists. “Scott and I started batting around vampire ideas very early on,” Rothbart recalled, “before he had even officially signed onto the film. We wanted these vampires to be very different from what people had seen before. We didn’t want guys with fangs in smoking jackets. These vampires were going to be more like creatures. Scott and I came up with some initial ideas, and then concept artist Chet Zar translated those ideas into a creature design.”

effects shots, divided among effects facilities on three continents. Svengali digitally extended exterior city sets built on the Warner Bros. lot, and also created all-CG establishing views of the oppressive metropolis, inspired by the environments in Blade Runner. Initially tasked with creating matte paintings that could be projected onto geometry, the Svengali team ultimately built a full-CG, 3D environment comprised of decaying skyscrapers, Orwellian video screens broadcasting Church propaganda, and smokestacks belching sooty black smoke.

Final designs illustrated an eight-foot-tall ‘drone’ vampire that was extremely emaciated, with internal organs somewhat visible beneath a milky, translucent skin. Stewart and Rothbart knew from the outset that such a vampire would have to be realized via computer graphics in virtually every shot. “We went through the process of developing suits,” stated Rothbart, “and we incorporated those where they best fit; but we knew that a significant amount of the action with the vampires would have to be done through CG.”

KNB EFX Group fabricated head-to-toe vampire suits, which would be worn by stunt performers for shots requiring physical interaction between a vampire and an actor or set piece. Rather than lifecast specific performers and build custom suits based on those proportions, KNB was tasked with creating generic suits and facial prosthetics that would fit on any six-foot-tall stunt person. “Generic prosthetics and suits are not the optimum way to go,” admitted KNB creature effects supervisor Greg Nicotero, “but since they weren’t sure which stunt people would be performing these characters scene to scene, they had us make suits and prosthetics that would fit anybody of a particular body size and shape. Once we manufactured the suits, we brought in stunt performers to audition them in the suits, and then modified the suits to better fit the people that we liked.”

KNB started the project by having its in-house designer, John Wheaton, fit Chet Zar’s original design over photographs of a six-foot-tall stunt performer. “It soon became clear that the proportions of the creature in the concept art weren’t going to fit on a human being,” Nicotero remarked. “The limbs were unnaturally long and the waist was very thin. So we had to re-proportion Chet’s concept a bit to make it work for the suit.”

Working from a lifecast of contortionist and suit performer Mark Steger, KNB artists Casey Love, Mark Maitre and Alex Diaz sculpted the vampire body, which, due to the translucent quality of the skin, would reveal underlying ribs, tendons, muscles and connective tissue. “We incorporated all of that in our sculpture,” said Nicotero. “In addition to the thin waist and the exposed ribs and barrel chest, it had knotted joints and three-fingered, gigantic claws with sharp talons at the end. It was a beautiful sculpture.” KNB made vampire feet, as well, although they knew the creature would be shot only from the knees up, since the suit would not have the backwards dogleg joint indicated in the concept art.

KNB’s Andy Schoneberg designed and sculpted the creature’s unusual head, depicted in Zar’s drawings as an eyeless skull with fangs. “Producers and directors always respond to an eyeless creature,” said Nicotero, “going all the way back to *Alien*. An eyeless character appears soulless, and

that makes it scarier. What I'm most proud of on the movie is that we were able to translate that look into a prosthetic. We sculpted the face over a lifecast of a stunt person, and then made generic prosthetics."

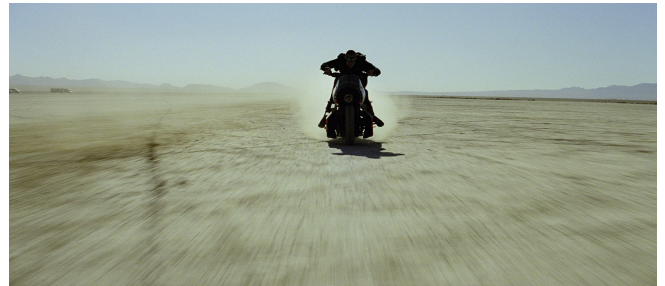
Prosthetic pieces included upper and lower lips, plus a full foam latex head with minute wrinkles that would enable stunt performers to see out of the enclosure, but were imperceptible from a mere five feet away. KNB also fabricated foam latex pieces to blend the neck of the suit onto the head. Blend appliances were required for areas of the suit, as well. "The vampires are completely nude," explained Nicotero, "so we had to blend off the gloves with prosthetics, the zipper in the back had to be covered, and we had to put blenders around the feet. Everything had to be carefully blended and glued down, because without any kind of wardrobe there was nowhere to hide seams."

In addition to six full-body suits and their accompanying facial prosthetics, KNB produced 20 full-size dummies for sequences featuring burnt and dead vampires. "We were able to adhere to the actual proportions of Chet Zar's original concept for those," stated Nicotero. "The dummies were jointed silicone, and they had armatures so they could be posed. We ended up shooting ten of them as they were, and then we set fire to ten of them for shots of the burnt vampires."

The film opens with a flashback in which a younger Priest leads an assault on Sola Mira, a labyrinthine vampire hive set within the caves and tunnels of a mountain. Stewart shot the scene's live-action on a 30-foot-tall set that was built on stage at Sony Pictures Studios. Spin VFX extended the set via 2D and 3D techniques.

An animated prologue follows, providing exposition of man's centuries-long war with the vampires. Viking Animation Studio — formerly The Orphanage Animation Studio — created the animated prologue, under the direction of venerated animator Genndy Tartakovsky.

The narrative then begins in earnest, moving to the industrial, smoke-filled City 5. Production had found locations around Los Angeles for city interiors, and had built exterior sets on the Warner Bros. lot, which were extended in postproduction by Svengali FX. The company also provided all-CG establishing shots of the city. "Svengali did a fantastic job of developing the city set extensions," noted Jonathan Rothbart,



To rescue Lucy, Priest mounts a motorcycle and ventures into the post-war wasteland beyond the city limits. Production shot wasteland exteriors at a dry lake bed in the California desert, which were then extended digitally by several vendors, including Spy. To create a wasteland night shot, Spy removed mountains in the original daytime plate and replaced them with a sky matte painting that was projected onto a half-dome in Nuke. Depending on the shot, Spy generated desert terrain by projecting footage shot from a speeding truck onto geometry, or by creating a shader and ground plane from scratch in Maya.



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“as well as the all-CG establishing shots. It was imperative that the environments look photoreal.”

geometry, or by creating a shader and ground plane from scratch in Maya.

The look of the city was inspired by the environments in *Blade Runner*, with the added element of an oppressive cloud of smoke and ash. “The concept is that there is constant manufacturing, and so smoke and ash are endlessly spewing out from industrial plants, creating this ever-present dark cloud over the city. The irony is that the ever-night condition of the cities has made it possible for the vampires to attack them during the daytime.”

Svengali visual effects supervisor Robert Nederhorst immediately understood the direction from Rothbart and Stewart to give the city a *Blade Runner*-esque look and feel. “*Blade Runner* is always one of my go-to references,” said Nederhorst, “and probably everyone in our business would say the same thing. So it was great to reference that film. I walked the crew through the ‘making of’ documentary to show them how the effects guys on *Blade Runner* had done it. They did some really smart things back then, and we mimicked some of those old techniques in the digital realm.”

To keep costs and man-hours to a minimum, production had initially tasked Svengali with creating City 5 matte paintings that could then be projected onto geometry; but, eventually, that approach proved insufficient. “As we got notes back from Jonathan Rothbart,” Nederhorst recalled, “we realized that what they really needed was a full-CG, 3D-built environment. At that point, we totally switched gears and changed our methodology on the show, using 3ds Max for 3D and V-Ray for rendering. In only three months, five guys — CG supervisor Mike Oakley, CG artists Nathan Millsap, Tharyn Valavanis and Carlos Fueyo, and modeler Shuichi Suzuki — built an entire CG city.”

Svengali’s final city environment was made up of decaying, ‘future-tech’ skyscrapers, many times taller than The Empire State Building, and smokestacks emitting sooty black smoke. At the hub-like center of the city is ‘Cathedral City,’ home to the governing warrior priests. “Digital matte artist Alex Nice did a ton of design work on that,” said Nederhorst. “Jbart and Scott gave us some good reference material, and then Alex and digital matte artists Bob Scifo, Rocco Gioffre, Marc Samson and others took off from that to design the city. Working in Photoshop, Cinema 4D and 3ds Max, we generated various permutations on a theme.”

Ubiquitous features of the city are large Orwellian video screens broadcasting Church propaganda. Confessions, too, are ‘heard’ by video screens, which dole out canned responses and boilerplate penances. Jonathan Rothbart worked with Dav Rauch, another Orphanage alum, to create all of the video monitor imagery. “We’d worked together to do the heads-up displays for *Iron Man*,” noted Rothbart, “and we designed the screen graphics for *Avatar*, as well. So Dav is my go-to person for doing screen work. They just shot empty screens on set, projecting green or blue light to create some interactive illumination shining on the actors.” Rothbart and Rauch created the video screen imagery, which was then composited into the blue- or green-lit monitors by whichever vendor was doing a particular shot or sequence. Freelance compositor Alex Henning, working out of his house, composited confessional booth monitors.

Astride a futuristic-looking motorcycle, Priest ventures into the wasteland that lies outside the city gates when he learns that his brother and his family have suffered a vampire attack and that his ‘niece’ — whom we later learn is his daughter — has been kidnapped by the creatures. Priest’s bike,

and others in the film, had been designed and built to suggest the story's otherworldly setting — but concern for riders' safety led production to have the bikes rebuilt with a more standard, and thus safer, front end. A variety of effects houses restored the original design in post, tracking and replacing the front end of the bike with a digital version.

Production shot wasteland exteriors for Priest's journey at a dry lake bed outside Victorville in the California desert. "When we were there," said Rothbart, "the lake bed looked enormous. But once we got into shots, we found that it wasn't nearly large enough. Mountains surrounded the area, but we needed to create a flat desert that went on forever. We tasked several facilities with replacing the horizons on wasteland shots."

The Senate Visual Effects contributed a montage of shots designed to suggest the passage of time as Priest treks across the desert. The Senate created three matte paintings, each a different wasteland setting, and then transitioned from one to the next and combined that with greenscreen elements of Priest aboard his bike. Each matte painting depicted not only a different location, but also a different time of day. "The first matte painting is approaching evening," explained The Senate visual effects supervisor Richard Higham, "the middle matte painting is at night, and the third one is dawn, the breaking of day. All three depicted a landscape that was quite alien and unusual, and yet photoreal. They pointed us toward some reference photography of strange, rocky formations, and we built up the matte paintings from that. Once we had the basic terrain, we put in photographic detail to give it a sandy desert feel. We also added in a sandstorm blowing across the landscapes, using some fluid particles in Maya, which really helped to sell the shot."

Once they had the completed matte paintings, The Senate artists scaled down the greenscreen element of Paul Bettany on the motorcycle, and hand-animated him slowly moving across the landscape. "It was just one long animation of him going across," said Higham, "with the bike in the same position as the shot fades from one matte painting to the next. We animated the lighting of the bike, obviously, but his position doesn't shift — only the environment around him does. And that really created a sense of time passing."

Accompanied by Hicks, Priest visits his dying brother at Outpost 10, a wasteland settlement. Production shot Outpost 10 exteriors on a salt flat in Trona, an old mining area near Edwards Air Force Base, and interiors on a set built at Sony. Gradient Effects removed background mountains, extended the desert location — often using desert footage production crews had captured from a Ford Explorer on location — and dotted the landscape with CG wind turbines, the energy source for outpost settlers. In addition, Pixel Liberation Front did some A/B composites to add the exterior to the windows and doors of the Outpost 10 interior.



To suggest the passage of time as Priest speeds across the desert, The Senate created a montage comprised of three matte paintings, each depicting a different location and time setting – from dusk to night to daybreak. Though realized with photorealistic detail, the matte-painted landscapes – such as one featuring massive stalagmite-type rock formations – were designed to suggest the alien nature of the film's alternate-reality setting. The Senate enlivened shots by adding sand and dust blowing across frame, created using Maya fluid particles.

Spy also extended desert settings, specifically for shots of a train moving through the desolate landscape, carrying a vampire army toward the densely populated city. Spy took different approaches to the desert extensions, depending on the needs of a particular shot. “In some cases,” said Spy visual effects supervisor Michael Janov, “we took footage shot from a speeding truck in the desert and projected it onto geometry representing the ground in Nuke, re-angled the projection as needed and retimed the footage based on how fast the train was supposed to be traveling in a particular shot. That worked for some shots, predominantly the lock-offs. In other scenarios, we made a shader for the ground in Maya, as well as a ground plane that went to the horizon, and did a transition from that to a matte painting in the background. That sky was done with a 2-D approach, where we created a matte painting and projected it onto a half-dome in Nuke.”



Zoic Studios also created wasteland settings, relying heavily on veteran matte artist Syd Dutton. Among Zoic's contributions was a matte painting of a ruined city overlooking a dry ocean bed, created for a scene in which Priest – accompanied by Hicks (Cam Gigandet), a young wasteland sheriff and Lucy's love interest – stops for rest and contemplation. Dutton based the underlying look of the ruined city on beach communities such as Santa Monica, and incorporated broken piers, derelict boats and salt deposits to depict the parched ocean bed.

Zoic Studios, which had been involved in the project under other directors a full four years previously, also created wasteland matte paintings as part of its slate of 60 shots. “When Jbart asked us to work on some of the matte paintings, we figured it was a great fit,” said Zoic visual effects supervisor Rocco Passionino, “in part because we have Syd Dutton here, who is a master matte painter. Jbart agreed that some of the wider shots would be perfect for his style of work.”

Among Dutton's contributions was a matte painting establishing one of Priest's stops along his journey — a ruined city atop a bluff, overlooking a vast ocean bed. “The idea was to create a beach community with a lot of collapsed buildings,” said Passionino. “The wasteland overlooked the dry ocean bed, which had salt deposits and piers and some capsized, derelict boats. We also did a 3D matte painting that was a top-down view of Priest and Hicks riding through this destroyed, sand-swept city, with torn-up roads and toppled buildings. It was a perfect visual to illustrate what has happened in the outside world as a result of the vampire wars.”

Priest and Hicks arrive at Nightshade, a penal colony for vampire prisoners of war. Production shot Nightshade live-action at Fort MacArthur, an abandoned military facility in San Pedro. Matte painter Eric Chauvin and his Black Pool Studios crew provided a wide establishing shot of the prison, creating a matte painting of a forbidding structure suspended above a deep chasm, surrounded by a series of bridges.

Zoic Studios executed a closer approach shot of Nightshade, significantly extending the Fort MacArthur set. “Production built quite a bit of the prison,” noted Passionino, “but they wanted the walls to be much higher, to get across the idea that there was no way for the creatures to escape. So we extended the walls up, created barbed wire fences all around, and added guard towers at intervals.”



Priest and Hicks arrive at Nightshade, a vampire detainment facility. Zoic augmented a modest set, extending walls upward and adding barbed wire fences and guard towers.



Priest and Hicks do battle with escaped vampires at Nightshade. Though the majority of vampire shots were computer animated, KNB EFX Group built dummy bodies and practical suits for quick cuts. Sculptor Mark Maitre inspects one of the vampire sculpts.

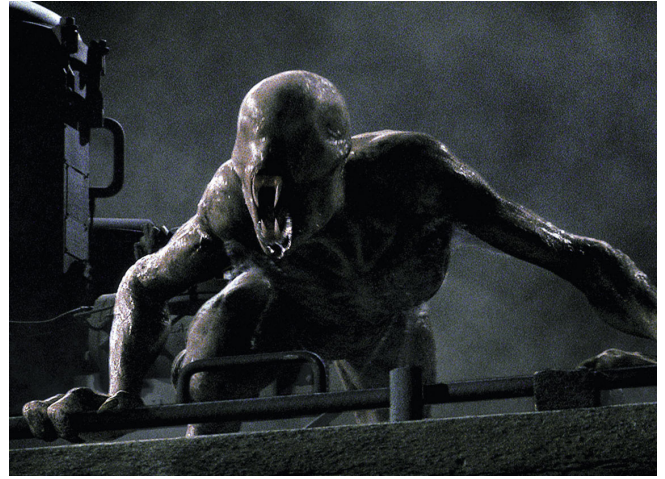


Vampire facial prosthetics included upper and lower lips, plus a full foam-latex head – designed without eyes, but with minute slitted wrinkles to enable stunt performers to see out. KNB show supervisor Andy Schoneberg and makeup artist Garrett Immel suit- up a stunt performer.



During filming of the Nightshade fight, stuntmen in marked gray suits stood in for CG vampires to aid lineups and camera framing and to create a sense of real physical interaction. In post, Tippet Studio painted out the stunt performers and replaced them with animated vampires.

Searching the prison facilities, Priest and Hicks discover that the vampire detainees have escaped, and are then confronted by ‘familiar’ — human beings that have been bitten by a vampire and become their slaves. With the setting of the sun, six remaining vampires engage Priest and Hicks in yet another fight. Production shot the fight sequence with stuntmen in marked gray suits standing in for the vampires. “We didn’t do any motion capture for the vampires because we didn’t want them to move like human beings,” Jonathan Rothbart explained. “But we had our gray suits there for purposes of lineups, to help with camera and to create a sense of real interaction with Paul Bettany and Cam Gigandet during the fight. We really wanted there to be a connection between the actors and the CG creatures — we were always concerned about fight scenes feeling too CG. So we had these stunt guys in gray suits fight with our actors, and then we painted them out and replaced them with our CG vampires.”



Tippett artists modified a CG model provided by the production to accommodate animation of the vampire’s frenetic, spidery movement. Facial animation for the eyeless creature was limited to slight brow movement to create fierce expressions, and the motion of very thin lips pulling back over vampire teeth and gums.

Tippett Studio animated the CG vampires in the Nighshade sequence, starting with a model that had been developed on the production side. “Because I knew the drone vampire was going to be split up between a couple of facilities,” said Rothbart, “I did the initial look development and modeling with Nathan Reidt in advance of any of the facilities getting that asset. That way, Scott and I could be very hands-on throughout that process. And then we handed it off to the guys at Tippett, who made a few adjustments and completed the look dev through their system.” Subsequently, Tippett Studio handed over the modified model and maps to Spin VFX — the other company charged with vampire animation — where they were tweaked again to suit that company’s pipeline.

Most of the refinements made to the model at Tippett Studio were necessitated by the creature’s unusual, frenetic movement. “Even though the vampires were built like a man, the filmmakers wanted them to be predominantly on all fours and move around in a spidery way,” said Tippett Studio visual effects supervisor Blair Clark. “The main reason for that was to make it clear that these characters were not performers in suits. Although the vampires were very emaciated and had the classic dogleg, they wanted one other aspect of the characters that felt very unnatural, un-human and creepy — and that was done through the movement. So we altered some of the joint placements and made a few other minor adjustments, without changing the overall design and feel.” Facial animation for the eyeless creature was limited to slight brow movement to create fierce expressions and the motion of very thin lips pulling back over vampire teeth and gums.

Tippett Studio art director Mark Dubeau worked with the studio's paint artists to develop the look of the vampire's flesh. "Jonathan Rothbart gave us really good direction for that," said Clark. "He said it should have the same translucent, milky quality as a spring roll. They wanted the skin to be so thin, you could see the muscles and bones and veins underneath."

The action cuts from Priest and Hicks at Nightshade to a vampire attack on the wasteland town of Jericho, a western-style outpost where the city-bound creatures stop to harvest 'food' in the form of Jericho's citizens. Production shot live-action for the sequence on the set built for HBO's postmodern western series, *Deadwood*. Working with production designer Richard Bridgland, Jonathan Rothbart helped to conceive a town that had a western flavor, but with the industrial aesthetic of the film's other locations.

The same small crew at Svengali charged with building City 5 built much of the town of Jericho, extending the single-story *Deadwood* buildings upward. "It was very much like the methodology we'd followed for City 5," said Rob Nederhorst, "where we started with 2-D projections as a target, and ended up building an entire post-apocalyptic western backlot to supplement the streets in the plates. The digimatte work looked great, but the 3D geometry and textures allowed us to really maneuver things around and re-purpose things in a way that is difficult to do in digimatte."

To make the build as efficient as possible, the CG artists assembled a kit made up of industrial pieces they had modeled for City 5. "If we needed more detail for something," said Nederhorst, "we'd just pull up the building kit and start attaching those industrial pieces to our CG buildings. There were probably 50 or 60 pieces in that building kit — pipes and pipe fittings, scaffolds, ducts, and all kinds of weird shapes." In addition to adding detail and interest, the CG pipes and fittings provided a connective infrastructure between the live-action and CG floors of the buildings. "We would clamp on these industrial shapes between the practical buildings and our digital extensions to blend the two together. We also added running wires and gantryways here and there. These parts and



*The filmmakers shot a scene in which vampires attack the outpost town of Jericho on a set originally built for the postmodern television western, *Deadwood*. Production designer Richard Bridgland and Jonathan Rothbart developed Jericho concepts that had a western flavor, but with the industrial aesthetic of the film's other locations. To realize the town design, Svengali extended the *Deadwood* buildings upward and added CG pipes, scaffolding, ducts and fittings, which provided visual interest and helped to connect practical and digital elements. Svengali compositors artfully blended the 3D set extensions into plates that were heavy with ambient smoke and atmospherics.*



*The filmmakers shot a scene in which vampires attack the outpost town of Jericho on a set originally built for the postmodern television western, *Deadwood*. Production designer Richard Bridgland and Jonathan Rothbart developed Jericho concepts that had a western flavor, but with the industrial aesthetic of the film's other locations. To realize the town design, Svengali extended the *Deadwood* buildings upward and added CG pipes, scaffolding, ducts and fittings, which provided visual interest and helped to connect practical and digital elements. Svengali compositors artfully blended the 3D set extensions into plates that were heavy with ambient smoke and atmospherics.*

buildings would be rendered, and in some cases the renders would be handed off to the digimatte artists to integrate in their paintings.”

Svengali compositors Anthony Kramer, Clancy Silver and Josiah Howison did some artful work to blend the fully CG, 3D set extensions into plates that were heavy with smoke and atmospherics. “It was difficult,” said Nederhorst, “and I am really proud of not only the CG work but the compositing work done there. We had night and day shots with varying levels of explosions, dust, debris and smoke in the plates.”

The Jericho sequence opens with a vampire crashing through the window of a home and attacking a family inside. “We shot that with a stunt guy jumping through a window and on top of an actor,” said Jonathan Rothbart. “And then he was removed and replaced with the CG vampire. Tippett Studio did that initial shot; and then Spin did the rest of the sequence, which had vampires attacking people all over the town.”

“Throughout the sequence,” explained Spin animation supervisor Peter Giliberti, “the vampires are jumping from scaffolding and walls and rafters, attacking the live-action actors on the ground. There was some of the spidery crawl movement we see in other sequences, but mostly these shots had the vampires doing really huge leaps, almost like a tiger attacking a victim; and so they had to have some weight to them. We showed Jonathan Rothbart variations of movement, and he liked the big leaping attack moves, where the vampires would pause and rear back just before they lunged at their victims.”

The choreography of the vampire animation was constrained by the timings and actions of the victim stunt performers in the live-action, who were pulled down and yanked out of frame via ropes and other rigs to suggest vampire impacts. “They had done all of that interaction stuff really well,” commented Giliberti. “You could tell they’d thought out the timings very carefully, figuring out how long it would really take for a vampire to go from one victim to the next. When integrating our CG vampire, we had to make sure that we matched our character’s actions and timing to that.” To create a real sense of physical interaction between victim and vampire, Spin artists matchmoved the live-action performers. “Every time a character was impacted by a vampire, we rotomated that character so we could find a good place for the vampire to tackle him and make real contact.”

The story moves back to Priest and Hicks, who have left Nightshade and are approaching Sola Mira, the vampire hive seen in the film’s opening. The Senate executed a matte painting for the Sola Mira approach, and Spin significantly extended interiors, shot on a small set on stage at Warner Bros. “The Sola Mira set was so small,” Jonathan Rothbart noted, “we essentially shot all of the scenes there looking in the same direction. I spent a fair amount of time moving rocks around and slightly redressing things to try and make it seem like a different spot in the set! We had to do a large amount of digital set work to disguise the fact that we were always shooting the same small area, and to create a larger scale hive.”

“The Sola Mira interiors required 3D set extensions,” added Spin visual effects supervisor Jeff Campbell, “because of the changing perspectives in the dramatic camera moves.” One extension involved a shot in which Priest, topside, throws a flare into the hive to determine its depth. “The flare was supposed to keep falling for the duration of the shot. They had shot a practical flare, but of course it just hit the practical floor of the set. We extended the flare going down into infinity, with the CG hive illuminated interactively from the flare.”



Priest and Hicks approach Sola Mira, a mountain housing the vampires' hive, comprised of a labyrinthine network of tunnels and caves. Sola Mira was a pivotal setting in the film, featured in the opening and in a sequence in which Priest and Hicks explore the vampire stronghold. Although multiple vendors contributed expansive extensions to a small interior hive set built on stage at Sony Studios, The Senate created the establishing matte painting for a wide view of Sola Mira as seen by Priest and Hicks as they near the forbidding peak.

Tippett Studio did its own Sola Mira interior extensions for its shots of Priestess — whom Priest and Hicks meet there — and Priest fighting off the ‘hive guardian,’ which appears as a vampire drone on steroids. “That was a fun sequence,” commented

Jonathan Rothbart, “because the fight moved all over the place, from the ground to high up on these rock walls. The hive guardian smashes rocks, and we used air mortars on set to create the impacts. At one point the hive guardian slams into Priest, who then barrels over the creature’s back. For that, we slammed an apparatus into the actor; and then he rolled over it, on a wire. Again, we were trying to keep the fight between a live actor and our CG character as interactive as possible.”

Tippett Studio fleshed out the hive guardian design, starting with some rough concept art of a drone vampire that had been scaled up and bent into an all-fours pose. “Mark Dubeau worked with lead modelers Mark Estrada and Miguel Ortega to come up with some really cool ideas for the hive guardian design,” said Blair Clark. “The final guardian was very bulky, with skin that was like rhino hide — so, in that way, it looked very different from the drone vampire. The facial characteristics were similar, though. To indicate some biological relation to the drones, it had no eyes, the same type of mouth and almost the same head, except on a much thicker neck.”

The guardian’s different body anatomy called for a very different style of animation, as well. “Our animation supervisor, Jim Brown, and the animators did a lot of tests to develop animation that would make the hive guardian feel heavy and bulky,” Clark recalled. “So whereas the drones were spidery and lithe and sinewy, with a lot of quick movements, this thing was more of a lumbering animal. One of the challenges was that he had these huge, muscular arms, but his body tapered down to much smaller legs. So it was always a trick to keep that from looking humorous — like the classic Tex Avery and Chuck Jones bulldog — when he was running.”

While exploring Sola Mira, Priest and Hicks find a cavern where hundreds of drone vampires are being bred for a new army — part of which is already on a windowless ‘night’ train, heading for the city. The cavern was a Sony set, extended via Spy matte paintings. Spotting Jericho in the distance, the characters go there to investigate, and find it desolate in the aftermath of the vampire attack.

“Svengali did those Jericho extensions, as well,” stated Jonathan Rothbart, “except now using a daytime set. The previous Jericho attack was a nighttime scene; this one is set in daylight, in the middle of a dust storm.”

Priest, Hicks and Priestess devise a plan to stop the train’s advance toward the cities and save Lucy, who is on board. Production shot action of performers jumping onto the train in the salt flat location, using a big-rig pulling four trailers dressed with train carriage facades. Spy extended the desert and

provided CG train shots to augment the practical rigs. “Whenever we could, we used footage of the full-scale ‘train’ they’d mocked up with the big-rig truck in the desert,” said Mike Janov. “We painted out the wheels of the truck, reconstructed it so that it looked like it had train wheels, and put a track underneath it. We then added dust and smoke to help integrate it into the plate. The reference from the practical truck in the plate was golden because it gave us all the information we needed as to where the light was coming from and what the dust looked like in the real world.”

Some shots required that Spy replace the practical rig entirely with a full 3D train, which the company based on a 1/12-scale train built at Kerner Optical for an explosion near film’s end. “I had taken photographs of the Kerner miniature — which consisted of a locomotive, tender, fuel car and box cars — from every angle before they blew it up,” said Janov. “We were able to use those for texture reference and build the train off of that. We duplicated the boxcars 21 times, and made a road map of what action took place on any particular spot on the train, so we would know how many boxcars were needed in each shot. If Hicks was jumping onto the caboose, for example, we knew we only had to build out cars 21, 20, 19, 18, because those were the only ones showing in the shot. We wouldn’t have to build out the entire train every time.” Another efficiency measure was ‘built-in’ animation that automatically put the train on the tracks in shots in which the train was moving at normal speed and traveling from Point A to Point B.



Inside Sola Mira, Priest and company fight off the ‘hive guardian.’ Tippet Studio fleshed out the look of the guardian, which had been designed only in broad strokes by the production art department. The final design was a creature with some features akin to those of the vampire drone, but bulkier, with thick, rhino-like hide. The guardian’s unique physiology required Tippet animators to develop lumbering moves that contrasted sharply with the frenetic actions of the drones. One of the biggest challenges in the animation was avoiding a comedic effect in running shots of the character, whose tapered body recalled that of a Tex Avery or Chuck Jones cartoon bulldog.

Spy also did motorcycle replacements for a shot of Hicks jumping onto the train from his bike, which continues rolling forward, out of control, and then crashes. “We created two different bikes,” explained Janov, “one for Hicks and one for Priest, which we also used for Priestess. We broke them out into two different 3D applications. For Hicks’ bike crash, we used 3ds Max, mental ray, Reactor, Krakatoa and Fume FX. We used Maya and mental ray for Priest’s bike, as well as the train and any other hard surface models.” When Hicks jumps off the bike, Spy did a hand-off from the plate to its CG bike. “Once it was CG we were able to direct the bike however we wanted. Effects artist Allan McKay made it look like it was wobbling out of control; and then we smashed the front end into the ground and made it tumble a couple of times, kicking up a lot of dirt and dust, which we did using Particle Flow, Krakatoa and Fume FX.”

Once onboard the train, Hicks makes his way inside, searching for Lucy and coming upon a car filled with pods in which the vampires sleep. Spin animated the vampires for the train interiors, and also created the cocoon-like pods, replacing practical pods that, in Scott Stewart’s judgment, did not look sufficiently organic or alive. “Based on our own fleshy pod concept work,” Jeff Campbell said, “we were asked to replace the practical pods in 23 shots. They were challenging shots because we had to roto out the actors and replace the entire environment with CG animated pods. The pods had to be lit with the actor’s flashlight beam, so we did volume light passes that were matchmoved to the original plate. Camera tracking was difficult because the only reference points we had were on pods that moved independently due to the rocking train motion. We accomplished the look using some pretty gross displaced veined textures, subsurface scattering and cloth sims. We animated the vampire model inside the pods, which drove the cloth simulations.”

To avoid rousing the sleeping vampires, Hicks moves quietly through the car; but the crash of Priest’s motorcycle into the train and the subsequent explosion awakens them. Spin realized shots of the pods breaking open and expelling both fluid and creatures. “We used Maya nCloth to sim all these pods ripping apart,” said Campbell, “and RealFlow for the fluids that pour out.”

Spin animated subsequent shots of the awakened vampires chasing Hicks through the train. “Those were big hero animation shots involving a lot of keyframed creature interaction,” said Campbell. “The vampires fight and climb over one another and jump off walls and boxes. Even the smallest



Having learned that a massive vampire army is heading for the cities aboard a windowless night train, Priest, Hicks and Priestess (Maggie Q) devise a plan to stop the locomotive’s advance and extract Lucy. To capture interaction of characters with the speeding train, production shot four trailers, dressed with carriage facades, pulled by a big-rig truck across a California salt flat.



Spy either replaced entirely or extended the trailer rig with its CG train. Most shots also required Spy to replace truck wheels with train wheels and to add the railroad track. Volumes of CG dust and smoke helped to integrate digital train components into the plates.

animation change in one creature created a domino effect that required the surrounding creatures' animation to be revised, as well."

The vampires' advance is stopped when Hicks blasts holes into the ceiling of the car, letting in beams of sunlight that hold them off for some moments. Spin generated the volumetric wall of light, as well as the burning flesh effects in shots of the vampires moving forward, into the sunlight. "Scott didn't want the traditional vampire-turning-into-ashes effect," said Campbell, "he just wanted them to get a really bad third-degree burn. For the transition, our compositor, Doug Campbell, used a light map that was cast from the volumetric lights above and revealed the burnt areas over time, going from the pass of normal skin texture to the pass of burnt texture."

Meanwhile, Priest and Black Hat (Karl Urban), the new leader of the vampire army, fight atop the roof of the train. To capture fight action, crews cut off the top of the big-rig train mockup after the salt flats shoot had wrapped and shipped it to Hansen Dam for an exterior bluescreen shoot. "We shot the whole sequence outside, against bluescreen, with the actors on the rooftop set piece," explained Jonathan Rothbart, "and then we created train extensions, where needed, as well as horizon extensions that we blended into our moving ground plates shot on the lake bed. That was one of the last sequences to get turned over, and time was short, so we had to split it amongst four facilities: Spy, Iloura, Zoic and Gradient. I had to do four of the last shots that came from an edit change myself."

Spy's work on the sequence included character animation to refine some of the fight action. "Some of the fight moves needed to be a little more over the top than what they'd done on the bluescreen stage," explained Mike Janov, "especially for some of the wide shots. So we did some animation of Black Hat and Priest in this fight, doing back flips and jumping from one car to another. We received cyberscans of the actors, rigged them up and did cloth animation. These were fairly distant shots, and the camera was moving quickly, so they were pretty forgiving."

Among the 204 shots contributed by visual effects supervisor Jim Hillin and his crew at Gradient Effects were 75 in the train rooftop fight. "Generally," recalled Gradient executive producer Thomas Tannenberger, "our shots involved bluescreen roto and matchmove tasks, and then compositing to get the backgrounds back in. We also did very limited train extension work. They had a few prop train cars on the bluescreen stage and we blended those into an environment and made them look as if they were moving fast by layering in CG dust and actual dust elements."

Another vendor brought on to work on the rooftop fight was Iloura in Australia, with Glenn Melenhorst supervising. "Ultimately we did about 65 shots," said Melenhorst. "We were pretty much a 911 call at the end of the film, when they had overflow. The work we did involved bluescreen and set and train extensions. The actors fought on a train set that was three carriages long, so we had to extend that and add the environment rushing by. We got basic train assets from other vendors, and we got a lot of reference plate photography for the environment.



During an altercation between vampire leader Black Hat (Karl Urban) and Priest aboard the speeding train, a flashback sequence reveals the former's transformation from warrior priest to vampire loyalist. In the flashback, a captured Black Hat is tied to a pedestal and attacked by a swarm of snarling vampire drones. Spin animated dozens

But we built the carriages ourselves and went through a re-texture process to get those shots where they needed to be.”

of interacting ‘feeding frenzy’ vampires for the scene, ultimately toning down the violence in deference to the film’s PG-13 rating.

During the altercation between Black Hat and Priest, a flashback sequence reveals the former’s transformation from warrior priest to vampire loyalist. After being captured, Black Hat is tied to a pedestal at a vampire stadium, where a drone swarm attacks him. Initially, the filmmakers had conceived a more violent and gory drone attack than what appears in the final movie. “Spin, which did this sequence, worked really hard to create blood effects and the interaction of the vampires gnawing on Black Hat in the scene,” said Jonathan Rothbart. “However, a lot of that was removed for the PG-13 rating. I guess we’ll have to wait for the DVD to see the original shot!”

Though the attack was toned down, the scene still features dozens of snarling, hissing, biting vampires. “We had as many as 42 vampires in one shot,” said Jeff Campbell. “They are all interacting — climbing over one another, pushing and slapping one another. They described it as an ‘orgy’ of vampires trying to get a forbidden taste of their victim.”

In an overhead shot, we see the vampires scatter with the arrival of the queen, who slits her arm and drops blood into Black Hat’s mouth, changing him forever. Spin also animated the queen, which — like the drone — had been modeled and developed on the production side by Nathan Reidt. “Our task was to rig and build shaders for the queen, as we had for the drone,” said Campbell. “But we were more involved in the look development of the queen because we were the only vendor with queen shots.”

Spin generated eye effects for the reveal of Black Hat’s transformation. “Using Inferno’s distort mesh, displacements and paint,” said Campbell, “I made the pupil dilate and then contract as all the veins and capillaries bugged out and turned red and sore.” Spin had done a much more prolonged and detailed transformation for an earlier scene in which Black Hat bites a salesman portrayed by Brad Dourif. “We had a head scan of Brad that I matchmoved and used to receive animated texture projections in Inferno. The projected textures involved veins creeping around his face and eyes, which were animated by paint reveals and bump-mapped for depth. His pasty skin and dark, sallow eyes were added using animated garbage masks over the duration of the shot.” KNB designed and fabricated dentures for the transformed Black Hat’s fangs.

Back on the train, Priest and Hicks confront Black Hat inside his cabin, which leads to the car being set on fire. “We shot with a minimal amount of flame while the actors were in the set,” said Jonathan Rothbart. “And then we completely blacked the set and shot a series of flame elements, burning the various areas of the set and matching to the shots. We wanted to avoid using CG fire. It was all practical or elements.” Alex Henning composited the flame elements into the live-action plates.



As Priest and Hicks deal with Black Hat and the vampires on the train, Priestess — tasked with detonating an explosion to stop the locomotive if their efforts fail — becomes embroiled in a fight with familiars near the train tracks. Gradient composited in a 2D desert environment, removed background mountains from the plates, and added CG tracks.

Gradient also replaced the front end of Priestess' bike with the digital version, did some complex rig removals and animated her metallic whip-like weapon, called a 'rope-dart,' which she uses to great effect against the familiars. "The rope-dart was fully CG," said Gradient executive producer Olcun Tan. "The actress had a reference prop in her hand during filming, just to give her an object to hold that had some weight to it so she could get an idea of how to move correctly. But we modeled the rope-dart completely as a CG object, and then came up with an all-new setup to make it behave correctly. The setup allowed us to simulate certain areas and keyframe others. It was important that we be able to control that through keyframing because there were specific directions we had to follow for the motion of the rope-dart." Gradient artists used HDRI maps to add detailed reflections on the weapon, which had a metallic sheen.

During the fight, a familiar is thrown off a motor-cycle and into the air above Priestess. She wraps her rope-dart around the airborne character, and slices him into pieces. In the next shot, pieces of the dismembered familiar fall around Priestess, which production simulated using cuts of pork and other meats. "Maggie's a vegan," observed Jonathan Rothbart, "so we couldn't have the meat in the shot with her — which we probably wouldn't have done, anyway. Instead, we threw pieces of meat off of a crane. Spy composited those elements, and also did the shot of the familiar being sliced up."

Starting only with a wire-rigged greenscreen shot of a performer flying overhead, Spy had to devise a means to chop up the familiar in mid-flight. "We ended up doing a hand-off from the plate to a digital character," said Mike Janov, "which we had pre-sliced, based on the animation of the rope-dart wrapping around him. Once we had the rope defined in the areas we wanted to cut, we pre-cut the digital familiar and passed it through a particle system. We attached each 'chunk' to a particle; and once it was a particle, we could orchestrate exactly how we wanted it to move. On top of that, we spawned other particles for blood and smaller bits and pieces of flesh coming off of him. It was pretty disturbing."

Due to the fight with the familiars, Priestess is left with too little time to set the dynamite — packed on the back of her motorcycle — on the tracks. Instead, she sets the charge and races her motorcycle toward the on-coming train. Still aboard the train, Priest jumps off with Lucy just before Priestess' motorcycle slams into the locomotive, causing a massive explosion. "The explosion was a combination of live-action plates and the 1/12-scale train that we built at Kerner," explained Jonathan Rothbart. "Brian Gernand supervised the crew at Kerner, and they did an awesome job. The detail on the train was just fantastic." Miniature pyrotechnician Geoff Heron orchestrated the explosion of the miniature, a one-take event that required Rothbart and his crew to cover it from multiple angles, using seven different high-speed camera setups. "That was fun, because I started

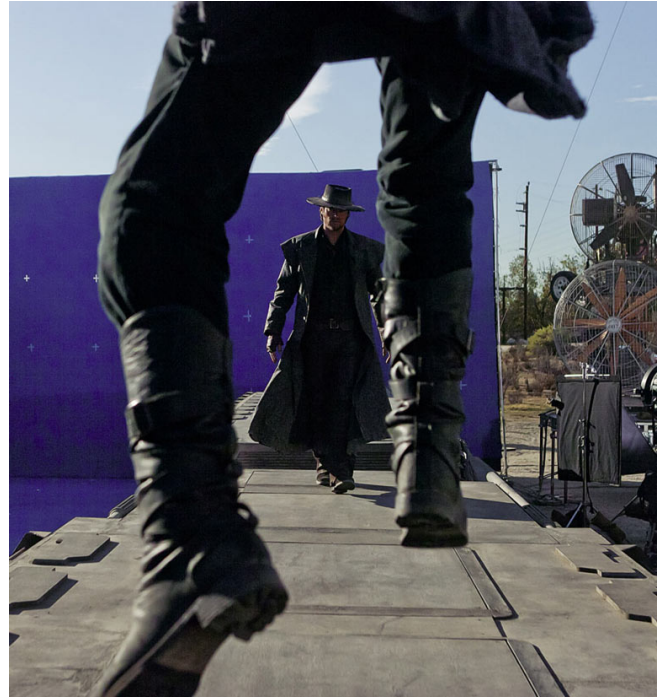
The feeding vampires scatter with the arrival of the vampire queen. Production developed and built a queen computer model, which Spin then rigged and animated in the shots. For Black Hat's transformation from human to vampire 'familiar' when the queen drops blood into his mouth, Spin used Inferno's distort mesh, displacements and paint to make the character's eyes dilate and then contract as surrounding capillaries bulged and turned red.

out at ILM and had spent a lot of time with the model shop guys. It was great to get back there. It felt like home.”

Spy composited the train explosion, extending and enhancing the miniature element. “We ‘match-imated’ our CG train based on the practical miniature,” said Mike Janov, “and used that information to get the speed of our CG train and help us figure out how it would derail off the tracks. We blocked out that animation so that Jonathan could buy off on the gross movement of the train. Then, from there, we brought the model into 3ds Max and did some morphing techniques with pre-shattered geometry to make the train look like a soda can bursting out the side. We created sliders linked to morph targets that would open the appropriate section of the train. Finally, we added in the practical effects, along with some CG explosions.”

Spy used Fume FX and Krakatoa to create the CG explosions, and added in subtle effects of dust kicking up off the ground, using practical elements shot by Mike Janov and Spy compositing supervisor Steve DeLuca. “We went out to the Presidio with my little Canon 7D,” Janov related. “We put some plexiglass in front of my camera, put up a little bluescreen, and then I shot it as Steve flung dirt around using his hands and a small shovel. He threw rocks into the dirt and slammed the ground with foreign objects — anything to make an impact effect. We didn’t know what the angles were going to be for the shot yet; and so we just built up a library of elements. It was a combination of the on-set miniature explosion debris, the practical elements that we already had in our library bank, these ridiculous elements that Steve and I shot, and CG effects. Combining all of the elements, we were able to put together something that was photoreal in a short period of time.”

Near the end of an intense postproduction, and after the 2D version of the film was in the can, several of the effects facilities worked on stereo conversions of their own shots for Priest. At Tippett Studio, CG supervisor Scott Liedtka oversaw the stereo



Priest and Black Hat fight on the roof of the speeding train. To capture fight action, crews cut off the top of the big-rig trailer mockup after the salt flat shoot had wrapped and shipped it to Hansen Dam for an exterior bluescreen shoot with the actors atop the roof set piece. Visual effects teams filled the matte areas with train and environment extensions blended into moving ground plates shot on location.



Model supervisor Nick D'Abo at work on a 1/12-scale, six-car train built at Kerner Optical for a sequence in which Priestess crashes her dynamite-laden motorcycle into the train.

rendering of about 20 shots. “The feeling was that it would be worth putting in a little extra time, effort and money into making these 20 shots, which featured closeups on our CG monsters, looking as good as possible,” said Liedtka. “The idea was that those shots would look better if we actually rendered both eye-views, rather than just do a post stereo process. So we used a more recent version of RenderMan, PRMan 15.1, to render out both eyes at once.”

A significant benefit of rendering out the left and right eyes together was that it eliminated stereo artifacting on shiny, specular areas of frame — a common problem due to the slightly different angles of the right-eye and left-eye cameras. “We would load all the geometry in our scene once,” explained Liedtka, “do the lighting calculations, and then PRMan would spit out the left eye and the right eye at the same time. The fact that the specular wasn’t recalculated for both eyes reduced our stereo artifacting. This is actually a limitation of the software — something we would have fixed if we wanted to get the correct specular highlight for each eye. But instead of a limitation, for us it was a feature. Using the specular highlight of one eye — even though it was ‘wrong’ for the other eye — actually worked better in a stereo situation, especially for shiny objects. Instead of having to go in and paint out artifacting frame by frame, we had this RenderMan trick up our sleeves. That really helped us out.”

To meet the demands of a heavy conversion workload, outside facilities joined the effort in the final weeks of postproduction. Tippet Studio, in addition to doing the conversion of its 20 hero shots, turned over Z-depth files for its remaining shots to *Legend 3D*, which had developed a mathematical approach to the stereoscopic process. “*Legend 3D* has tools that enable them to use Z-depth files as input to calculate what the stereo space should be,” explained Liedtka. “In the old days — and they’re not that old — vendors did it more by eye; and many of them still do it that way.”

By juggling effects shots between many vendors, Scott Stewart and Jonathan Rothbart were able to complete all 800 of the visual effects shots for *Priest* on a budget that was as thin as its vampires’ waistlines. “We did a lot of moving shots around to save as much money as possible,” concluded Rothbart. “We had vendors from Los Angeles to San Francisco to Vancouver to Toronto to the U.K. to Australia, which meant very long days for our team, due to the different time zones. It was a real challenge, but largely due to my producer, Jenny Fulle — who was just magical in making it all work — we got it done.”

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On the company’s bluescreen stage, the Kerner Optical crew prepares to shoot the train explosion – a one- take situation covered by seven high-speed cameras to ensure adequate coverage. Spy combined that miniature pyro element with its CG train geometry – burst open like a soda can via sliders linked to specific morph targets – and blended in additional practical smoke and fire effects and CG explosions.

First Class Effects

image

article by
Jody Duncan

Set in the early 1960s, *X-Men: First Class* explores the deep friendship between the young Charles Xavier (James McAvoy) and Erik Lehnsherr (Michael Fassbender), the nascent congregation of mutant forces—for good and for ill—and the potentially cataclysmic historical conflict that leads to an unbridgeable divide between the lifelong friends.

Marvel Entertainment and Twentieth Century Fox entrusted their latest collaboration to director Matthew Vaughn who, from his base in London, joined with visual effects designer John Dykstra to develop visual effects primarily aimed at illustrating the powers of mutant characters, especially those new to the *X-Men* films. “We spent a fair amount of time designing the powers of the new characters,” recalled Dykstra, “using a lot of still artwork to determine what the different powers would look like in their fully rendered forms. We tried to keep the mutant powers somewhat subtle — at least in a relative sense — and retain all the subliminal clues of physics with regard to motion and the way that objects interact. Subtle visual clues and cues were really critical, and that’s what we focused on in the making of these characters.” As concepts came together, Vaughn and Dykstra moved from still artwork into animatics and full previsualization of major sequences. “Rpin Suwannath was seminal in the execution of the previsualization, working with some great artists both in-house and at The Third Floor.”

Vaughn shot much of the film at Pinewood Studios, but ventured out to locations around London, and in Georgia, Washington D.C., the Mojave Desert and Argentina. The filmmakers also shot on stages at Fox Studios in Los Angeles at the tail end of production. On set, 4dMax, a small U.K. company, used its new Mephisto scanning technology to do cyberscans of the cast and props, generating data that would be crucial to the visual effects teams. 4dMax also lidar-scanned all of the sets at Pinewood and at the Georgia locations, using the company’s newest Leica HDS C10 laser scanner.!

To help create a ‘60s-era film aesthetic, Vaughn made the decision to shoot *X-Men: First Class* anamorphic. “The idea was to create a sense of wide-screen presentation, which is emblematic of ‘60s movies, such as the *James Bond* films,” John Dykstra commented. “Scope was important in those kinds of movies, and it was important in this one. We wanted not only to see the characters in this movie, but also the entire period world around those characters.”

Dykstra and his visual effects producer, Denise Davis, divided the film’s visual effects shots among several effects facilities, each of which took primary responsibility for a particular sequence or mutant character. The only mutant requiring little visual effects support was *Beast*, portrayed throughout the film by actor Nicholas Hoult in a makeup designed and executed by Amalgamated Dynamics Incorporated and makeup supervisor David Elsey.

Although *Beast* had been established in previous *X-Men* movies, Matthew Vaughn sought to take the character in a new direction, and engaged teams both in London and Los Angeles to generate designs prior to ADI's involvement. "I flew over to London and looked at what had already been done in terms of design work," Alec Gillis — co-founder of ADI, with Tom Woodruff Jr. — recalled of his introduction to the project. "They had one piece of Photoshop artwork that they kept referring back to, but it was more the feeling of what they wanted than an actual design. The sense I got from the director was that he wanted a clean break from what had been done before. He wanted something that was less human looking and more animalistic."

While in London, Gillis also looked at a *Beast* bust sculpted by David Elsey, who would soon win an Oscar, with Rick Baker, for the makeup effects in *The Wolfman*; and when he returned to California, Gillis incorporated some of its features in his own sculpture, working over a lifecast of Nicholas Hoult. On a return trip to London, Gillis collaborated with Elsey on a third bust. "I took that sculpture back to ADI," said Gillis, "where sculptor Glen Hanz did the finishing work on it, blending edges and adding texture."

David Elsey would remain integral to the creation of the *Beast* makeup, working from a studio at Pinewood with his wife, Lou Elsey. As Gillis and the Elseys began producing makeup tests and presenting them to the director, it became clear to all of them that the characteristics of *Beast*'s fur were a critical component of Vaughn's vision of the character. "He saw a big difference, and rightfully so, between hair and fur," recalled Gillis. "If we put a wig on something for a test, Matthew would not have a good reaction to it. We finally realized that what he wanted was a fur-based creature, with something akin to a wolf's pelt on his face, his arms — everywhere. Dave and Lou showed him some beautiful fur samples — both real and synthetic — and Matthew preferred the real pelts."

ADI artists fabricated final *Beast* prosthetics in foam latex, creating a back-of-the-head and neck piece, a muzzle and lower lip, ears, and tear ducts for the corners of the eyes to create an animalistic look. Due to the lederhosen-type suit *Beast* wears throughout the film — ADI also built foam latex pieces to cover the actor's legs from the knees down and his arms from the elbows down. Meanwhile, back at Pinewood, David Elsey made teeth that would give the character's face a feral quality.

The Elseys, in addition to applying the makeup on the set throughout production, also did the final painting and hair-punching on the facial prosthetics, while ADI did the finishing work on the *Beast*'s body, hands and feet for hero suits, as well as those for stunt performers. Both teams used fox pelts for the character's fur. "We went through quite an elaborate dying process to get those pelts to be the right color," noted Gillis. "And then, once we cut the hair off of the pelts, we had to brush out the under-fluff — the deep hair that gives the animal its warmth — so we were left with just the shaft of each hair. Then we punched those into the legs and arms, making sure that his blue skin was visible underneath." Well into the shoot, Fox suggested that *Beast* look more ferocious — and even more animalistic — for the film's third act; and so, Elsey sculpted a new *Beast* forehead appliance to give the character a more furrowed brow. ADI ran the forehead appliances and applied them to the existing facial pieces.

While *Beast*'s look was entirely a makeup effects creation, the transformation of scientist Hank McCoy into *Beast* was among the 120 effects shots contributed by MPC. The transformation begins when McCoy attempts to 'cure' his mutant affliction — manifested in a simian-like foot — by injecting himself with a DNA-altering serum. Initially, it appears that the serum has worked, and his simian appendage takes on the appearance of a human foot. Within moments, however, the foot changes back to its simian form, and then continues a transformation into an even bigger — and furrier — *Beast* foot. "His hands begin to change, as well," explained MPC visual effects supervisor Nicolas Aithadi. "We don't see it on camera, but the suggestion is that his entire body is changing." Originally, the sequence had been designed to reveal the entire transformation; and so, MPC built a head-to-toe CG *Beast*. Vaughn later decided that he wanted to show only the deforming hands and feet, as if from McCoy's POV, and save the full *Beast* reveal for later in the film. "In the last shot, he falls to the ground and you can see his face a bit — but it is very distorted through a glass beaker in the foreground."

MPC modeling lead Caroline Delen and modeler Laurent Herveic incorporated a great deal of detail in the *Beast* appendage models to accommodate shot designs that had the camera lingering, in closeup, on the morphing features. "All the models had the same topology," said Aithadi, "so we could make seamless transitions from one to the next. Each had to look completely real and fleshy, with fat and veins and skin, all moving in an organic way. To do that, we developed a system in which we used the rig to drive displacement maps. Animating the rig triggered the displacement maps, which made the veins pop up, and the tendons and muscles move. On top of that, we built blend-shapes that would create wrinkles and folds of fat, also triggered to move at specific points in the animation. MPC animation supervisor Benoit Dubuc and his team were in charge of triggering all of these intricate details. We also ran cloth simulations for the trouser leg and shirtsleeve. Cloth is always difficult; but in this case it had to be perfect because the camera was so close you could actually see tiny fibers at the edge of the trousers." MPC replaced the practical *Beast* face in a couple of shots of the character opening his mouth wider than what could be executed by Hoult in the makeup.



X-Men: First Class explores the genesis of the rift between the young Charles Xavier (James McAvoy) and Erik Lehnsherr (Michael Fassbender). Director Matthew Vaughn entrusted visual effects designer John Dykstra with developing effects shots that would illustrate the super-powers of mutant characters and creates-era environments. Erik and Charles talk over a game of chess on the steps of the Lincoln Memorial. A team from Rhythm ... Hues, one of several effects contributors to the film, shot stills at Washington D.C.'s National Mall over a 24-hour period, and then tweaked those images to create period backgrounds that would accommodate shots set at any time of day or night.

Another of MPC's X-Men assignments was creating the effects for Riptide (Alex Gonzalez), a mutant with the power to whip up tornadoes at will. MPC first generated the base of the effect, which was made up of multiple caches of lighting and other digital elements that could be mixed and matched in compositing. The team then embellished the tornado with practical elements shot on stage. "We built a tornado machine," explained 2D supervisor Arundi Asregadoo, "and used that to create little tornadoes out of dry ice and that sort of thing, giving us elements that we could spin off from the core of the tornado. Playing with that machine, we learned a lot about the characteristics of a tornado and how it behaves at different speeds."

Among the most difficult of MPC's tornado shots were those set inside the Hellfire Club, a gathering place for mutants of a criminal bent. "We had seven tornado shots set in a Hellfire Club room," noted Nicolas Aithadi, "and a room is not the best place to create a tornado! A tornado is usually made up of dust and dirt and whatever else it can suck up — but there was nothing to suck up in this room. So the tornado had to be made of nothingness. After a lot of time, we finally came up with something that looked vaporous, like a tornado of gas."

Another complex tornado sequence has Riptide destroying the Cerebro dome — featured in previous X-Men films — during an attack on a secret, CIA-like government compound. "We used Kali — a fairly new in-house rigid dynamics simulation tool — for the destruction of the building," explained Aithadi. "We created a massive volumetric tornado using Maya Fluid, and some of those sims were so big, they required a couple of days of computation."

MPC created large-scale destruction of another type for a sequence in which Erik Lehnsherr uses his metal-controlling powers to destroy a yacht belonging to rival mutant Sebastian Shaw (Kevin Bacon) by wielding the boat's massive anchor. Production shot interiors for the destruction sequence on a real boat in the waters off Jekyll Island, Georgia, and then MPC replicated the vessel in CG for exteriors. "We had to completely destroy a full-frame CG boat," Aithadi noted, "with all the detail that required. We scanned and did a texture shoot on the real boat, and then we built it to a



The film's central antagonist, Sebastian Shaw (Kevin Bacon), incites his fellow mutants to revolt against their human oppressors. Among Shaw's operatives is Emma Frost (January Jones), whose mutant power enables her to morph into diamond form. Rhythm ... Hues, responsible for the 'diamond girl' shots, rotomated to January Jones in the live-action plates, meticulously matchmoving every nuance of her performance, and then applied the highly reflective and refractive CG diamond effect to the rotomated character. To make her facial expressions read more clearly, Rhythm ... Hues artists retained the actress's eyes and lips from the original plate.



Digital Domain realized shots relating to Shaw's mutant power, which is the ability to absorb energy, making him invulnerable to attack. To create a visual representation of that power, dubbed the 'kinetic echo,' artists at Digital Domain built a Shaw digital double, and then animated ripples, deformations and, in some cases, multiple limbs and tracked them to the actor in the live-action plates. Digital Domain executed all of the character work in Maya, and ran some geometry through Houdini to accentuate deformation effects. Shaw manifests multiple hands to contain and absorb a ball of fire.

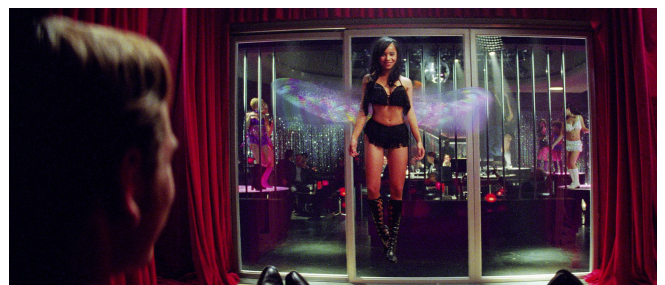
very high level of detail — every cushion, chair, bottle and plank.” MPC also built the craft’s steel understructure and cabin interiors, which would be revealed as the anchor tore through the boat.

MPC effects lead Joan Panis and his team utilized Kali to create the actual destruction, and used a combination of Flowline and a custom shader to simulate the water around the floating vessel. The shader was based on the Tessendorf algorithm, which accurately represents the look of water. “We implemented the algorithm,” explained CG supervisor Mohammed Sobhy, “which allowed us to build the base of the ocean water. And then, for interaction with the boat and splashes, we layered a Flowline water sim on top of that. That inherited the base properties of the algorithm, but allowed us to get all the dynamics and interaction, as well.”

Surviving the attack, Shaw amps up his efforts to build a mutant army. Digital Domain, under the leadership of visual effects supervisor Jay Barton, was responsible for effects relating to Shaw, whose mutant power is the ability to absorb energy of any kind, making him invulnerable to everything from gunshots and body blows to grenade explosions. Conceptualizing how that power would manifest itself, visually, was one of the major challenges of the visual effects assignment. “I didn’t want a big light effect for Shaw absorbing energy,” John Dykstra commented. “We all agreed that we wanted to make this more physical, something where we would see him displace and deform in a very organic, kinetic way. We started with illustrations of the character undergoing these physical distortions; and then we codified more specifically what would happen under different conditions. We created our own scenarios about how Shaw would react to the various energies he absorbs over the course of the film.”

Artists at Digital Domain rendered Photoshop artwork to further define the displacement effect, dubbed the ‘kinetic echo,’ which has ripples and deformations running through Shaw’s body. “The more forceful the energy he absorbs,” said Jay Barton, “the more he displaces and the more he gains in mass.” Digital Domain created a digital double for Shaw, and then animated the displacement on the CG character and tracked it to the actor in the live-action plates. “In some cases we completely replaced Kevin Bacon. In other scenes, we augmented his performance, adding the CGI ripples and deformations. We did our character work inside Maya, and also pumped some of that geometry out through Houdini to accentuate some of our effects.” In one scene, Shaw absorbs the energy from a grenade that goes off in his hand, and then ‘grows’ multiple arms to encircle the explosion and arrest its progress. “He is completely taken over by a digital double in that case so we could create the multiple arms and increased mass. We also did some interesting cloth simulations to get the sleeves on all of those arms.”

Shaw endures a barrage of submachine-gun fire and rockets in one of the film’s biggest action sequences, dubbed the ‘Men in Black’ sequence due to its setting at a secret government headquarters staffed with agents in black suits and narrow black ties. Digital Domain prevized the scene, which begins with Shaw walking into a large atrium at the entrance of the headquarters, in search of mutants



Mutant Angel Salvadore (Zo’ Kravitz) exhibits her ability to fly via wings that sprout from her tattooed back. Rhythm ... Hues modeled the wings, based on those of a dragonfly, in ZBrush, and then animated them to

being held there. Soon, he is assaulted by dozens of armed guards.

Production shot the scene's live-action on a 30-by-60-foot atrium set surrounded by greenscreen.

Digital Domain extended the set and added the

Shaw effects. "Throughout that," observed Barton,

"he grows multiple appendages and has

displacements running through his body. Then, when it's all done, he stomps his foot and uses all of that absorbed energy to destroy the entire building. That starts with a large displacement at his hip, which travels down his pant leg and hits the floor as his foot makes contact. That, in turn, sends a shockwave through the floor, to the back wall and radially around the room, breaking concrete and gas lines, causing explosions and all of this mass destruction. We created all of that in our digital set. We also did some CG stunt doubles for guards running in the background, using motion-captured stunt material that we shot with John Dykstra. We had guys on wire rigs doing flips and tumbles, running, falling and firing weapons. We used all of that to populate this large space."

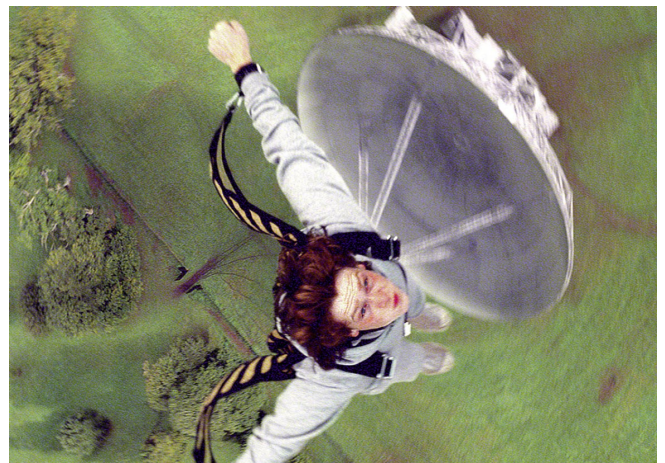
The Shaw effect is on equally dazzling display in a climactic sequence in which he engages in combat with Erik in a mirrored room above a nuclear reactor core. In addition to generating dramatic Shaw effects for the scene, Digital Domain created the entire mirrored environment. "The mirrored room wasn't something that could be shot practically, of course," Barton explained. "We shot a couple of inserts in a real mirrored room, just to get the feeling of what it would look like; but ultimately we shot that scene wide open with a greenscreen background, and then we added in the mirrors and the hundreds or even thousands of reflections of the two characters fighting."

Digital Domain worked with John Dykstra to determine the dimensions and configuration of the room. The final environment was comprised of eight mirrored sides and measured approximately 15 feet in diameter. "We'd learned in experimenting with it that an even number of sides gave us a hall-of-mirrors effect, if the angle was right," said Barton. "We could rotate the room a little bit and see a hundred Shaws facing a hundred Magnetos. But we could accentuate the foreground, if we wanted to, just by rotating the room at another angle and turning the background reflections into noise."

The all-CG shots also featured animated digital doubles of Michael Fassbender and Kevin Bacon engaged in fight choreography. "On top of that," said Barton, "we had to do Shaw's displacement effects and effects related to Magneto's flying metal objects around the room. The whole sequence grew, as well. It started out at something like 20 shots, but it was a 60-shot sequence by the time we were done."

Digital Domain collaborated with Luma Pictures on a sequence in which Shaw has a confrontation with Havok (Lucas Till), an energy-generating mutant. While Digital Domain did the Shaw displacement for

'bloom' from a digital tattoo tracked to Kravitz'unmarked body. Animators referenced slow-motion footage of dragonflies to create an authentic fluttering wing pattern, with appropriate 'figure-eight' cycles and lag times between the movements of the large and small wings. Custom shaders provided the wings'translucent, iridescent quality.



Luma Pictures supplied effects for Banshee (Caleb Landry Jones), whose powerful primal scream creates sound

the shots, Luma created the energy effects for Havok. "Havok's power is a light-based phenomena," explained John Dykstra. "Again, we started with illustrations and explored things such as air distortion as a means of showing his power. Ultimately, we came up with the idea of rings as a way to manifest his unharnessed energy."

waves capable of launching him skyward. Production shot Jones in a flying rig against greenscreen to produce the mephistophelean Azazel (Jason Flemyng). Ginesite created elements that Luma then reframed, placing them on cards inside Nuke the character's teleportation effects, basing the look on that previously established for Night Crawler – son of Azazel in X-Men lore – and also animated and tracked a computer generated tail to the actor in the live-action plates.

Concentric rings make up a beam of light, which emanates from Havok's chest, burning and destroying everything in its path. As Havok learns to better control his power, he develops the ability to create large circular bands of energy that he uses as thrown weapons against his opponents. The disks were animated effects, timed and choreographed to match up to Lucas Till's mimed throwing of them in the live-action plates. "We had to matchmove to his actions in the plate," said Luma visual effects supervisor Vince Cirelli, "and choreograph the disks so that they worked with the performance. Since the actor wasn't actually holding anything, his hands would move a little closer together or farther apart as he mimed throwing the disks through the scene — which meant the disks had to dynamically stretch and deform based on locators matchmoved onto the actor's hands." In addition to generating the energy effects, Luma built a Havok digital double and tracked it to the performer, enabling artists to relight the character as necessary to reflect the interactive illumination from the light effect itself. "We had to build out some basic geometry for the lighting interaction on the environment, as well."

In Havok's confrontation with Shaw, the latter absorbs the energy rings and then forces open the mouth of the mutant Darwin (Edi Gathegi) to deposit them there. Darwin's mutant power is the ability to morph into materials such as metal and stone. "Darwin tries to contain all of that energy by changing into different materials," said Cirelli. "They had shot the Darwin actor with the camera rotating around him 360 degrees. Using a scan of the actor, we created a CG Darwin to do the transformation from the human Darwin to his metal and then stone forms. He doesn't just blend from one material to another. There are transition zones that bleed across his body as he goes from one material to the next. John Dykstra had the idea of the effect crawling across the surface based on bone densities. We generated several custom maps that, when output, looked like a topographical map and were triggered at render time."

Luma also generated effects relating to the character of Banshee (Caleb Landry Jones), whose primal scream is so powerful, it creates sound waves capable of large-scale destruction. “Banshee generates and controls frequencies to destroy the objects and materials around him,” related John Dykstra. “It’s similar to the singing woman shattering a wine glass. But how do you make those frequencies visible? I started looking at things like schlieren photography, which shows the disruption of a gaseous environment by the introduction of energy. The most common schlieren image is that of a moving bullet — you see the ‘V’ of the shockwave at the tip, and it is usually red and blue, or red and green because the air being displaced by the bullet is compressed and as a result it refracts the light, much like a lens. We started with that as an idea for the look of the Banshee effect. Using optical distortion, a lensing of the background through which the frequency is moving, we made a visible representation of the path of those waves of frequency from his mouth to whatever he was influencing. It looked similar to a fighter jet breaking the sound barrier.”

To create the sound wave effect, Luma artists started with rigged geometry, just as they had for the Havok energy beam. “The difference was that we weren’t actually rendering any of that geometry,” said Vince Cirelli, “we were just using it to drive simulations. We created what looked like air distortions rolling through space, with wisps and turbulence. To create a sense of instability in the sound waves, we used cloth simulations to drive dense particle and fluid sims within Maya.”

In some scenes, Banshee uses the power of sound to enable him to fly. “He screams toward the ground,” said Cirelli, “and the resulting sound waves stir the air and give him lift. For the flying, they shot the actor in a 360-degree flying rig. They did such a great job of shooting all of that, in terms of lighting and choreography, it really didn’t look like an actor against greenscreen. We animated and reframed



The only mutant requiring little visual effects support was Beast, portrayed by Nicholas Hoult in a makeup created by Amalgamated Dynamics Incorporated and makeup supervisor David Elsey. Though Beast had appeared in a previous X-Men film, Matthew Vaughn encouraged the creature effects team to take the character in a more animalistic direction. A critical component of the new look was fur derived from real fox pelts, meticulously punched into foam latex prosthetics.



David and Lou Elsey fit prosthetic pieces to Hoult.

what was shot, placing the elements on cards inside Nuke. We changed the lighting slightly, added some flicker, and put depth haze in front of the actor. Generally, whenever Banshee was close to camera in the flying shots, we used the plate. When he was mid-distance or far from camera, we went to a digital double.”

Though not an entirely new character — she had been featured briefly in *X-Men Origins: Wolverine* — the ‘diamond girl,’ Emma Frost (January Jones) qualified as one of the most challenging in *X-Men: First Class*. Rhythm ... Hues took up that challenge. “Diamond Girl was really difficult,” observed John Dykstra. “We were dealing with a surface that was both reflective and refractive, so it was similar to making a glass character — but it had to look like diamonds. So the difficulty was to make it transparent and reflective and refractive, which we already knew how to do, but with the added visual cues that would make her read as diamonds. Part of it was the index of refraction — how it bent the light that passed through it — which is very different in a diamond than it is in glass. The facets had to be very sharp, as well, because diamonds don’t have irregularities in their edges. On top of that, we had to integrate January’s features and her performance into this faceted surface. Even though it was made up of all these reflecting and refracting facets, the surface had to be continuous and smooth enough to make her features readable.”

Rather than keyframe-animate a CG diamond character, the Rhythm ... Hues team, under the guidance of visual effects supervisor Greg Steele, rotomated to January Jones’ performance in the live-action scenes. “We were religious about matchmoving every nuance of her performance,” Steele said, “down to the most subtle motions of her fingers and the little twitches in her face. Because she’s reflective and refractive, any small jitter in her body was amplified, so the match had to be absolutely perfect. We would match it the best we could, and then make slight adjustments, where necessary.”

Rhythm ... Hues applied the diamond look to the rotomated character, tweaking and art directing the visual cues on a shot-by-shot basis. Jones’ face required the most meticulous and artful work. “It was always a struggle to make her ‘read,’” stated Steele, “especially when it came to her face. We introduced a lot of diffuse shading to help us see her facial performance. The other thing that helped was keeping a bit of her real lips and eyes from the plate. We built up eyelashes and other features to enhance the look, and ran a sim to make her hair move like crystals in a chandelier.”



The Elseys were responsible for applying the makeup throughout production, based at Pinewood Studios.

Reflected and refracted in the diamonds is the surrounding environment, which Rhythm ... Hues captured in high dynamic range imagery. "Often, we had to tame the high dynamic range imagery to reduce the number of rays hitting the diamond form," said Steele. "We'd do refraction that was mathematically correct, but when we looked at it, it was too noisy, with too many different colors being reflected. The only way to see that, of course, was to render it. So it was an iterative process of working our way through it."

"For example, in a lot of shots, you'd see the ceiling being refracted behind her, but that wasn't the color we wanted to see. So we would project the plate onto the geometry for the rest of the environment — we'd do the HDRI — and then go in and paint on different maps just to make sure everything looked right. We could adjust the refraction bit by bit, almost like it was on a slider, until we got the right amount of sparkly quality."

Emma's first transition from woman to diamond form occurs in the Hellfire Club, where she uses her telepathic abilities to manipulate an elderly general. Erik interrupts her villainy, and then uses his magnetic powers to restrain her, wrapping a metal bed frame around her crystalline neck. "We created a CGI bed frame to interact with her," said Steele. "Later, they asked us to amp up the intensity of that and apply more pressure to her. So we created cracks that appear within the diamond surface as the bed frame applies pressure to her neck."

Rhythm ... Hues also contributed shots relating to Angel Salvadore (Zo' Kravitz), whose mutant feature is a pair of iridescent wings that sprout from her tattooed back. "We had two sequences where you see the wings grow out of her back," explained Steele. "We also had to track the tattoo on her because most of the time, she didn't have a makeup version on in the plates. So we matchmoved her body to enable us to track the tattoo to her, and then have the tattoo 'bloom' into wings, which we modeled in ZBrush. We put a lot of effort into making the wings look really good, ensuring that the iridescent quality read well. We created it through some shaders that we wrote, and it gave the wings a beautiful quality."



Jennifer Lawrence plays a younger Raven Darkholme, aka Mystique, in X-Men: First Class. Spectral Motion artists created the Mystique makeup – as they had for previous X-Men films – transforming Lawrence into the blue, scaly shape-shifter via custom silicone appliances. Rhythm ... Hues replicated the character digitally to realize Mystique transformations, which were designed to suggest a physical occurrence, rather than optical trickery. Though each transformation was unique, the effect generally began with small, feathery scales rising from the surface of Raven's human flesh and then laying down to form her blue skin. Rhythm ... Hues executed the effect using Voodoo and its proprietary 3D compositing package.



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Rhythm ... Hues animators were just as meticulous in creating the wing animation, referencing slow-motion footage of dragonflies in flight. "In that footage," said Steele, "we could clearly see the pattern of the wings' movement. We'd roughed out some animation, initially, according to what you'd think the patterning would be; but when we started deconstructing this footage, we could see how the patterning worked — not just the figure-eight move of the primary wing itself, but also how it related to the other wings, the lag between the top wings and the bottom wings, and the slight blowing of the membrane. Replicating all of that went a long way toward making the wing movement look realistic."

Rhythm ... Hues' slate of Angel shots grew when the filmmakers made the decision to increase her role in the third-act action sequence set off the coast of Cuba, where U.S. and Soviet Union fleets go nose-to-nose in an alternate version of the Cuban Missile Crisis. Originally, Angel had been featured only in a beach fight sequence; but in the final film, she joins Havok in flying out to the ships at sea. "There's now a big dogfight sequence out where the ships are," explained Steele. "That's the kind of thing that would often be done with digital doubles and a few greenscreen inserts; but they actually hung stunt people from helicopters and flew them around in the waters off San Pedro, filming them from other helicopters. It wound up looking really great because it was real. Our job, in addition to putting the wings on Angel, was to remove all of the stunt wires and harnesses the performers were wearing." Production shot additional wirework for the sequence on the greenscreen stage in Los Angeles. "One of the most difficult things was just cutting from the amazing live aerials to a greenscreen shot. It was difficult for them to get the same energy and speed on stage that they had in the aerial work — even though the same second-unit director, Brian Smrz, shot both. He used the same long lenses and he shook the camera around a lot, but it was a challenge to make the stuff shot on stage match what had been shot in San Pedro."

No *X-Men* mutant character has made a more indelible impression on audiences than Raven Darkholme — aka Mystique — portrayed in her younger incarnation in *X-Men: First Class* by Jennifer Lawrence. As they had for previous films, Mike Elizalde and his makeup effects crew at Spectral Motion created the Mystique makeup, transforming Lawrence into the blue, scaly, yellow-eyed shape-shifter. Spectral Motion adapted its molds for Rebecca Romijn, the original Mystique, to run

blue skin. Rhythm ... Hues executed the effect using Jennifer Lawrence plays a younger Raven Darkholme, aka Mystique, in *X-Men: First Class*. Spectral Motion artists created the Mystique makeup — as they had for previous *X-Men* films — transforming Lawrence into the blue, scaly shape-shifter via custom silicone appliances. Rhythm ... Hues replicated the character digitally to realize Mystique transformations, which were designed to suggest a physical occurrence, rather than optical trickery. Though each transformation was unique, the effect generally began with small, feathery scales rising from the surface of Raven's human flesh and then laying down to form her blue skin. Rhythm ... Hues executed the effect using Voodoo and its proprietary 3D compositing package.



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custom silicone appliances. “We had to modify some of the appliances and resculpt others completely from scratch, based on the new actor’s lifecast,” Elizalde stated, “but she still looks like she did in the previous movies. They didn’t want to stray too far from the look because it had been established so firmly after all this time.” Elizalde oversaw the first Mystique makeup test in London, and then turned over the day-to-day application to Lufeng Qu, who worked with a team of six local makeup artists.

Spectral Motion also created pieces for a ten-year-old Mystique (Morgan Lily) who appears in the film. “We made some interesting changes to the young version of Mystique,” said Elizalde.

“Obviously, you can’t subject a ten-year-old kid to six hours of makeup, so we designed a Mystique slip-on bodysuit and facial appliances for her. She had to sit still for the hour and a half it took to get those pieces on, but the rest of it was just a matter of slipping on this bodysuit.”

Rhythm ... Hues replicated the young and adult Mystiques digitally in order to realize shots of the character transforming from one shape to another — a look that had been well established in the previous films. “The Mystique transition is the Mystique transition,” said John Dykstra, “but Rhythm ... Hues took it to another level of sophistication and made it a more physical, rather than optical effect. Effects people had done a lot of hard design work for the Mystique transformations in the earlier movies; we just had the chance to stand on their shoulders and take it to the next level.”

Though each transformation would be different, based on where Mystique was and from what person/form she was changing, R...H’s version of the effect generally began with very small, almost feathery scales rising from the surface of her human flesh, and then laying down to form her blue skin. “We used Voodoo for that,” noted Greg Steele, “as well as our own 3D compositor, which is similar to Nuke.”

A particularly tricky transformation was one involving Young Mystique, who returns to her true form after impersonating Charles’ mother. “What made that transformation more complicated was the scale difference between the adult woman playing Charles’ mother and the little girl,” commented Steele. “Fortunately, John Dykstra had worked it out with the previz guys early on. On the set they built a platform that they could lower beneath the floor. They lowered the adult actress on that as the camera moved back, which helped us to make the transition from her to the smaller girl.”

Among the non-character-related shots done by Rhythm ... Hues is a period view of the reflecting pool in Washington D.C., as seen from the POV of Erik and Charles on the steps of the Lincoln Memorial. A Rhythm ... Hues team went to Washington and shot stills of the entire area, and then rebuilt the environment. “We shot stills at the Lincoln Memorial during a 24-hour period,” recalled Steele. “We weren’t sure what time of day this shot was going to be, so we made sure we were there for an entire 24-hour cycle, and wound up with 12 images for them to select from. Fortunately, most of the things built around there since the 1960s — the Vietnam War Memorial and the Korean War Memorial — were hidden behind trees, so we didn’t have to do too much to remove them. The *World War II* Memorial is at the end of the pool, though, so we had to take that out. We shot some people bluescreen, and added them walking around the reflecting pool area. We also added cars, birds and flapping flags in the background — anything to give it some life.”

R...H augmented a hangar set for a scene in which Charles reveals the X-Jet to his X-Men. Weta Digital, which would contribute most of the third-act action in which the jet figures prominently, modeled the aircraft and gave that asset to R...H for its hangar shot. “It was an absolutely beautiful model,” said Steele. “We had that, as well as a plate of the actors in a real hangar that was much too small. So we reconstructed the entire inside of it, and also changed the view outside, to make it look like an airfield. Everything was replaced in that shot except the actors.”

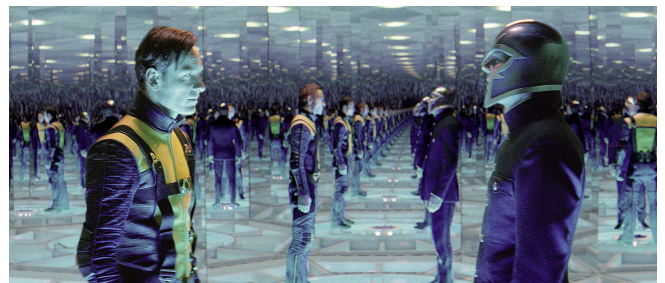
R...H also did three shots for the ‘*Men In Black*’ sequence, two of them aerial views of the headquarters. “We started with stock footage of a school in England they’d found,” said Steele. “Originally we were just going to augment the plate, because the school had kind of a 1960s vibe. But in the end, the only things they wanted from the plate were the grass and trees surrounding the school. We replaced the building entirely, working from concept art and a basic model from the art department. We embellished that, creating an additional quad, and cobbling it together with a quad set they had built in London.”

For shots revealing the aftermath of Shaw’s attack on the compound, R...H added smoke, fire and building destruction to a plate shot at the front of an office structure in Thousand Oaks. R...H did one shot for the actual attack sequence, as well, in which the devil-like Azazel — actor Jason Flemyng in a makeup designed at Spectral Motion — grabs government agents, teleports them into the sky, and then drops them to their deaths below. Cinesite, which would generate the teleportation effects, realized shots of Azazel airborne with his victims, but R...H did shots of those victims actually falling from the sky, toward the building below. “Because we were doing the building, it made sense to have us do this shot,” said Greg Steele. “They shot a bunch of greenscreen people on descender rigs. We took the falling motion from those people, rotomated them and created digital doubles to add more bodies falling in the background.”

John Dykstra and his preproduction team had designed the look of Azazel’s teleportation effect, basing it on the look of Night Crawler’s teleportation as seen in previous films. “In *X-Men* lore, Azazel is Night Crawler’s father,” said Dykstra, “so there had to be a connection between the way he teleports and the way we saw Night Crawler teleport in past movies. We echoed the inky, smoky qualities of that earlier effect, but we also added fire and smoke components, since Azazel’s got a Beelzebubean quality to him.”

Cinesite used Maya Fluids to create the teleportation effects. “Just before he appears,” explained Cinesite visual effects supervisor Matt Johnson, “there is this brief burst of flame that opens up around him and envelops his body. What’s left is a trail of red and black fluid smoke. We did the fluid sims so that this smoke would hang there for a bit, and then dissipate and drift away. Lead effects TD Steve Shearston designed those Azazel fluid sims.”

Cinesite, as part of its slate of Azazel shots, tracked and animated a computer generated tail to the live-action character. “There are a lot of fight scenes with



Erik and Shaw prepare to engage in combat in a mirrored room, a computer generated setting realized by Digital Domain. Digital Domain artists started with greenscreen elements of the battling actors, which they surrounded with CG mirrored surfaces featuring hundreds or thousands of the characters’ reflections. The sequence included some all-CG shots with digital doubles of

this character,” stated Johnson, “and in those, he uses his tail to lift people up and pull machine guns out of their hands and that sort of thing. It was an interesting animation challenge to make the tail feel like an extension of him, and to choreograph its action — especially in big scenes like at the MIB headquarters, where we had a live-action gun battle and stunt guys on wires.”

Michael Fassbender and Kevin Bacon performing animated fight choreography. Complicating the entire scene were Shaw displacement effects and CG metal objects flying about the room as Erik employs his magnetic powers. The initial 20- shot sequence expanded to 60 complex effects shots in the final cut of the film.

In addition to its character work, Cinesite revamped the ‘Cerebro’ effect, with CG supervisor Anthony Zwartouw helping to create a retro take on the high-tech device featured in previous *X-Men* outings. As before, Cerebro consists of a large domed room and a special helmet that enables the wearer to track mutants. To suggest a more low-tech Cerebro, as befit the period, production built a set that consisted of a raised platform surrounded by a metal framework, dressed with old-style tape computers. “They surrounded that with a 360-degree greenscreen cyc,” said Johnson, “and then we created the Cerebro dome as a 3D environment, lighting it carefully to match it to the set.”

The helmet, too, was designed to read as a piece of hardware from the 1960s. “It had wires coming out the back and was self-illuminating,” said Johnson. “There were automated lighting cues on set so there was ambient light, which we reflected in our CG environment. Keeping with the ‘60s retro vibe, we put in some old-school elements like lens flares and chromatic aberration and edge fringing. I’m not a fan of digital lens flares, so we used practical lens flare elements.” The same retro look applied to the Cerebro effect itself, which consists of images flashing by as the operator searches for mutants. “We gave that a more organic, less digital look. We shot a bunch of extras against greenscreen with different camera moves, and then we laid out and prevized images whizzing by those characters, with smoky fluid sim auras surrounding them.”

Cinesite’s contribution to the film extended to creating 1960s settings in all-digital establishing shots. One depicts a Soviet military parade in Red Square, circa 1962. “I wanted as much of it as possible to be photographic — again, fitting in with the style of the movie — and so I traveled to Moscow with visual effects photographer Aviv Yaron,” Johnson stated. “We went to Red Square and shot it for a few days, using a Canon EOS-1D Mark III stills camera and a robot-controlled pan/tilt head. On day one, we shot it from ground level, and also did 360-degree panoramas at very high resolution, specifying frame rates with this robot-controlled head, which would then set the tile distances for us.”

While the ground-level imagery would provide texture reference, the elevated angle of the actual shot required that Johnson and Yaron shoot the second day from the second story of a department store opposite the Kremlin. “We weren’t able to encapsulate the full pan from just one window due to the architectural features of the building,” noted Johnson. “We had to do a series of pans from different windows and buildings down the length of the square. And then we took all of those images and used them as photogrammetry for modeling the



Weta Digital was responsible for an effects- heavy third-act battle sequence that starts off the Cuban shore — where U.S. and Soviet fleets are engaged in a tense face-off — and then moves onto The Island’s beachhead. Weta created shots featuring a simulated ocean, 3D ships,

geometry. We created Red Square using that 3D geometry, and then utilized Nuke to do a series of projected images and photographs to create other aspects of the square.”

missiles and X-Jet, with dense effects work for explosions, missile fire and attendant smoke. The battle action begins with the arrival of the first-generation X-Jet, designed to resemble the real-world SR-71 Blackbird reconnaissance aircraft. Weta modelers built each panel of the X-Jet individually to ensure a high level of detail.

Johnson found footage of the actual 1962 Red Square parade on YouTube, and referenced that to determine what types of vehicles and military hardware his team would add to the shots. “We drove tanks and other types of Russian military hardware through the square,” said Johnson. “We also added in a Massive crowd, waving flags and celebrating, and digital marching soldiers. Fortunately, one of the military extras at Pinewood had been in the Russian army. So we had a little shoot with him doing a Soviet-style march. I shot it with parallel video cameras for animation reference. We roto-animated the march step, and that’s what we fed into Massive to create the army. We did a bunch of texture shoots for that, as well, photographing different uniforms.” Compositing supervisor David Sewell composited the Red Square shots.

In an alternate reality sequence, Shaw — on a platform — addresses his mutant army from a site in Washington D.C., in ruins as the result of a nuclear attack. “We start on the platform, which was a greenscreen element,” said Johnson, “and then the camera spins around and cranes up to reveal several thousand mutants in uniform, and this destroyed Washington D.C. in the background.”

While Cinesite used Massive to create the mutant throng, ADI supplied makeup effects for mutants standing on the dais with Shaw. “We did about seven different makeup characters at the last minute for this scene,” said Alec Gillis. “With very little time available, we went through pictures of past makeups, and said, ‘Well, there’s a cool brow piece from *Bedazzled*, and here’s a bony, sunken skull face from our Ridley Scott tests when he was doing *I Am Legend*.’ We Photoshopped some stuff, presented them with about ten different options, and they picked seven. We reused some appliances out of our stock, repainted them, and just fit them on people we got from a cattle call. It was like the old days — no time and minimal input from the director or the studio.”

Approximately 350 shots went to Weta Digital, which was responsible for most of the third-act battle that starts off the Cuban shore — where the U.S. and Soviet fleets stand ready to start *World War III* — and then moves onto *The Island*’s beachhead. “Of the 350 shots we did,” noted Weta visual effects supervisor Guy Williams, “only about 200 of them were comps. The rest were really heavy 3D shots of jets flying around and boats blowing up and shooting missiles. There was a lot of high-resolution CG work, and a lot of effects work that went on top of that.”

The high-rez CG work included shots of a freighter ship — which figures heavily in the final battle — at sea. “All the shots of this freighter out in the middle



To capture action inside the jet, with X-Men on board, production built a fuselage set representing the front two-thirds of the aircraft. Crews mounted the set on giant roller wheels to enable them to spin it – with actors strapped into seats for safety – for interior shots of the X-Jet rolling upside down as it attempts to evade missile fire or, for a later sequence, crashing and rolling onto the

of the ocean were all-CG shots,” stated Williams.

“One shot pans across the top of the freighter, from a height of only about 20 feet; another pans along its side. We did a handful of really big CG shots like that.”

The third-act action begins with the X-Jet arriving on the scene and hovering over the fleets of ships below. To capture live-action aboard the X-Jet, production had built and shot on a fuselage set representing the first two-thirds of the aircraft, which was mounted on giant roller wheels. “The way they had it set up,” explained Williams, “the wheels could spin the fuselage down its long axis to create shots of the airplane rolling upside down.” The wheeled setup enabled the crew to film shots — seen later in the sequence — of the jet, with X-Men aboard, crashing and rolling on the beach. “They strapped the actors into the seats and spun it around a few times.” The stage setup was surrounded by greenscreen, into which Weta comped CG skies and water.

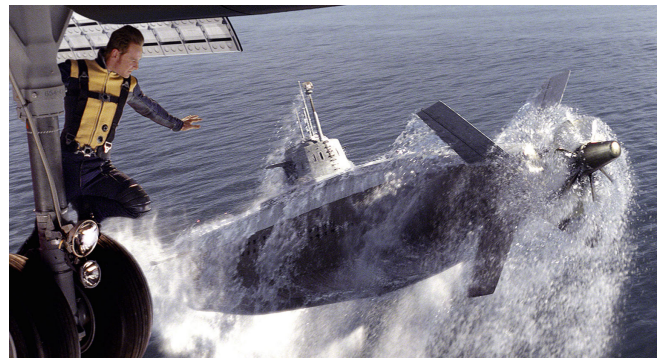
Similarly, production had captured live-action material aboard ships by shooting actors on a small bridge set with windows looking out to a greenscreen erected 25 feet away. “We did the water and environment extensions for those shots, as well,” said Williams, “putting in the ships and the horizon. So, except for the small bridge set, those shots were all digital. The ships, the water, the wakes, the effects from the ships — like the smoke from the smokestacks and gunfire and missile fire — were all done digitally.”

Each of the two fleets was made up of seven ships, which Weta modeled to reflect those of the 1960s era — taking some artistic license. “The ships were all those that existed during that era,” remarked Williams, “even though, technically, some of them weren’t in service in 1962. We did create a fictional Russian ship, the Kresta III, which was just a much bigger version of the real-life Kresta I and II cruisers. So we cheated a little bit, but we were very faithful to the implements and the design styles of the real ships of that time.”

Counting the freighter, Weta modeled 15 ships, each made up of hundreds of thousands of polygons, making efficiency a core issue in the build. “We built only the simple hulls of the ships,” Williams

explained, “and then individually built and published the conning towers and other pieces that the modeler would employ to assemble complete ships. Since we’d individually published everything — guns, missile launchers, doors, windows, lights, smokestacks, and conning towers — it became a Lego-block thing to put everything together to form a ship. It was a more efficient way to build these ships because, since all of the pieces were published uniquely, each would read its shading and texturing from that unique location. So when we changed the layout of a ship, it didn’t have to go

beach. Weta composited CG skies and water into the stage setup’s greenscreen backing. To capture action inside the jet, with X-Men on board, production built a fuselage set representing the front two-thirds of the aircraft. Crews mounted the set on giant roller wheels to enable them to spin it — with actors strapped into seats for safety — for interior shots of the X-Jet rolling upside down as it attempts to evade missile fire or, for a later sequence, crashing and rolling onto the beach. Weta composited CG skies and water into the stage setup’s greenscreen backing.



Erik climbs onto the landing gear of the X-Jet and uses his magnetic powers to raise an enemy submarine out of the ocean depths. Weta built an extremely high-resolution retro-style submarine model for the shots, and used its state-of-the-art fluid simulation tools — developed for the company’s work on *Gulliver’s Travels* and *Avatar* — to create large volumes of water streaming off the rising sub.

back through texturing or shading. This method allowed us to do these very complex ships with tons of detail and still leverage the modelers' time well." Cloth-simmed signal flags and digital double sailors added a sense of activity to the digital ships.

Just as detailed and high-rez as the warships was Weta's model of the X-Jet, featured throughout the third-act confrontation. "It was designed to look a lot like an SR-71 Blackbird," remarked Williams, "but much bigger. And unlike the SR-71, it has four lift engines on the bottom of it so it can hover. We built a lot of detail into the X-Jet, and all of its panels were modeled individually."

Tensions between the two international superpowers mount when Azazel — aboard Shaw's submarine below — makes his way topside to kill the crew of the freighter, the plan being to start a war by driving the ship through the middle of the American blockade. Charles averts the disaster by using his telepathic powers to compel a sailor aboard one of the Russian ships to fire a missile and sink the freighter. "The missile fires off the ship," stated Williams, "flies through the air, and then comes down and blows the freighter in half. There were three or four shots of that, all done digitally with fluid sims and volumetric explosions."

Weta created a digital double Banshee for shots of the character jumping out of the X-Jet and diving into the ocean to locate the enemy submarine, enabling the X-Men to hover over the sub's position, 50 feet above the water, as Erik climbs down onto the landing gear. Production had shot Michael Fassbender clinging to full-size landing gear on a greenscreen stage. Weta surrounded the greenscreen element with the X-Jet, water and skies, and animated a digital double Erik in some of the shots.

Erik uses his magnetic force to raise the 250-foot-long submarine out of the ocean — a stunning visual featured prominently in the film's trailer. The sequence features both wide shots and those fairly tight on the submarine, for which Weta built yet another extremely detailed model. "The sub, as it was designed by the art department, combined features of submarines from the '40s and '50s," Williams said, "so it didn't look like any sub we've seen before. Overall, it had a *World War II* look, with railings at the top and a shape that wasn't nearly as water-dynamic as they build now."

The company made prodigious use of its state-of-the-art fluid simulation tools — developed for Weta's work on *Gulliver's Travels* and *Avatar* — to create volumes of water streaming off the submarine as it rises out of the ocean. "There are huge amounts of



For relatively close shots, film crews shot Michael Fassbender on a greenscreen stage, clinging to full-size landing gear.



A tornado disrupts Erik's magnetic hold on the sub, causing it to crash onto the beach. Production shot the

water pouring off the sub in those shots,” noted Williams, “much more than there would be in reality. If you really pulled something like that out of the ocean, the amount of water running off of it would diminish considerably in the first five seconds. But we kept water streaming off of this thing for about a minute! That was all done with fluid sims on top of the CG renders. In the simulation software, we hid hoses that continuously pumped water onto the top of the submarine, creating this beautiful waterfall coming off all the exposed surfaces.”

aftermath of the crash in Georgia, on a Jekyll Island set dressed with a finished middle section of the sub – for in-camera shots of actors against sub wreckage – and green buck shapes at the front and back ends to allow for digital sub extensions. Post production changes in the sub design led Weta to replace the practical set piece with its digital model, as well.

Riptide climbs aboard the rising submarine and creates a massive waterspout tornado, which Weta generated using Naiad and its own fluid simulation software. “We used a combination of those tools to create a swirling particle cloud,” explained Williams, “and then we used those particles to emit volumetric fluids. The volume is what we actually rendered, and then we sweetened it with more of the particle stuff to create a sense of water droplets coming off of it.”

The waterspout disrupts Erik’s magnetic hold on the sub, causing it to drop to the ocean and then crash onto the beach, revealed in a five-shot vignette. “We did a lot of complex effects work to create the impact of the sub on the water,” said Williams. “For reference, we looked at images of large barges being launched, which creates a huge amount of explosive water.” Weta’s effects department generated similarly large-scale destruction effects for shots of the sub’s beach crash. “It does three or four revolutions on the beach; and, as it rolls, its spine breaks in two pieces, panels pop off, it knocks over palm trees in its path and kicks up sand. It was a heavy destruction sequence.”

Meanwhile, Riptide's tornado rips a wing off of the hovering X-Jet, causing it, too, to crash onto the beach, breaking into four large pieces that tumble along the sand and finally come to rest against palm trees. Production had shot the actors on a beach set on Georgia's Jekyll Island dressed with X-Jet and sub wreckage. The latter was represented by a green buck on which a middle section had been finished and painted to allow for in-camera shots of the actors against the wrecked submarine. Weta artists extended the set piece at the front and back ends, and ultimately replaced the practical set piece with their digital model, due to late-date changes in the design. "We get really close to our digital sub in some of those shots," said Williams, "sometimes within ten feet; and so, we had to up-rez those shots even more." The art department had dressed the beach location with three X-Jet pieces, as well, and built the fourth as another green buck, which Weta replaced in post with a section of its digital jet.

When the filmmakers determined, in postproduction, that a greater sense of destruction was needed at the crash site, they charged Weta with creating it digitally. "It made sense," Williams said. "You've just had a sub and a jet crash onto a beach within 200 yards of each other — it couldn't look like a beautiful spring day on the beach. So we added a lot of smoke and fire. We put in massive black clouds of smoke lifting into the air, white smoke drifting through the foreground, and spot fires everywhere. In some shots there are as many as 20 spot fires dressed around the set. They had done some smoke on the set, but you can't go to a place as beautiful as Jekyll Island and put 100 tires on the ground and set them on fire. On top of that, it was really windy there some days, so what little smoke was there would just blow right off the set. So we added these big piles of fire belching black smoke into the air."

The mutants of the opposing factions — Charles' X-Men and Shaw's band — engage in battle on the beach. Weta shared beach fight shots with other vendors, who provided the mutant power effects related to their assigned characters. Weta added the digital ships in shots looking out to sea, and digitally altered the Jekyll Island shoreline to make it look more like Cuba. Weta also worked on shots of Banshee flying over the fleets with Angel, executing the same type of work Rhythm ... Hues had done for the sequence, removing stunt rigs worn by the Banshee stand-in as he was flown, by



A battle between opposing mutant factions on the beach is interrupted by a barrage of missiles fired from the U.S. and Soviet ships offshore. Weta built a half- dozen different styles of missiles, authentic to the period, for the barrage sequence. Battleship and destroyer models, too, were more or less appropriate to the period, although Weta took some artistic license to include vessels that were not technically in service at the time the film takes place. Since each of the CG ships was comprised of hundreds of thousands of polygons, Weta artists modeled only the hulls, initially, and then built attendant pieces individually for efficient assembly and lighting from shot to shot.



After killing Shaw, Erik beseeches his compatriots to fight non-mutants – their ‘ real’ enemies – rather than one another. In addition to dressing the live-action scene with heavy CG smoke, spot fires and the crashed X-Jet in the background, Weta Digitally altered the Jekyll Island shoreline to make it look more like Cuba's. X-Men: First Class ends with Charles – having sustained a gunshot injury that will leave him wheelchair-bound – and Erik ending their friendship and setting divergent courses as future mutant leaders.

helicopter, over the ocean in San Pedro. In some cases — such as a shot of Banshee flying over the top of a ship and along the side of another — Weta replaced the aerial footage with a Banshee digital double.

In the course of the beach battle, Erik kills Shaw and implores his fellow mutants to fight humans, not one another. As if to prove his point that it is humans who are the mutants' enemy, the crews aboard the ships choose that moment to fire dozens of missiles toward the beach. "The missiles were high-resolution models, as well," said Williams, "because there are times when they're full-frame. We created six or seven different types of missiles for this 'missile barrage' sequence. It's a cool scene with beautiful explosions going off and a lot of wide shots of missiles flying through the air."

Erik stops the missiles in midair, and then turns them back toward the ships, intent on striking them despite Charles' protestations. Dr. Moira MacTaggart (Rose Byrne) begins firing a pistol at Erik to stop him, and in repelling the bullets, Erik inadvertently lodges one in Charles' back — an injury that will leave him permanently wheelchair bound. Devastated by the tragic turn of events, Erik spares the ships and lets the missiles drop into the ocean.

X-Men: First Class concludes with Charles and Erik going their separate ways, each to seek his own divergent course as a mutant leader. John Dykstra, with a long list of visual effects credits to his name, found himself in an unusual position as the show's postproduction came to a close and the various effects houses delivered their final shots — that of being more than satisfied with the contributions of every vendor. "You almost always have vendors that you're not entirely happy with," Dykstra observed. "But I have absolutely no complaints about any of these companies. Everybody did a great job for us. We had the right vendors, and the right teams within those vendors — and it was really our visual effects producer, Denise Davis, who made that happen. She's the one who brought all these great effects teams together, and I'm convinced we couldn't have found any better."

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